Title: POWER STEERING DEVICE AND METHOD OF CONTROLLING THE POWER STEERING DEVICE
Inventor(s): Mitsuo SASAKI et al.
DOCKET NO.: 023484-0222

FIG.1

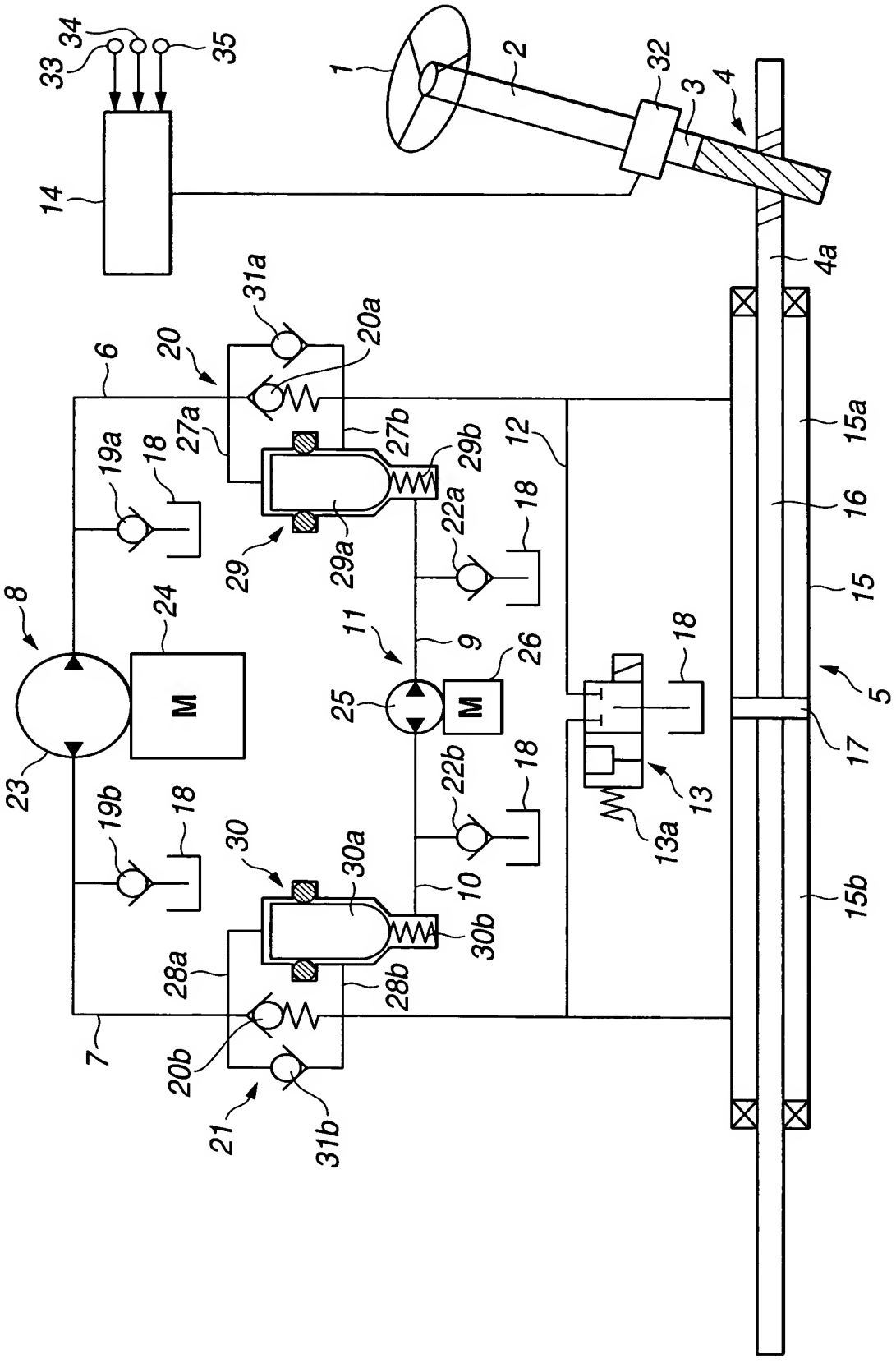
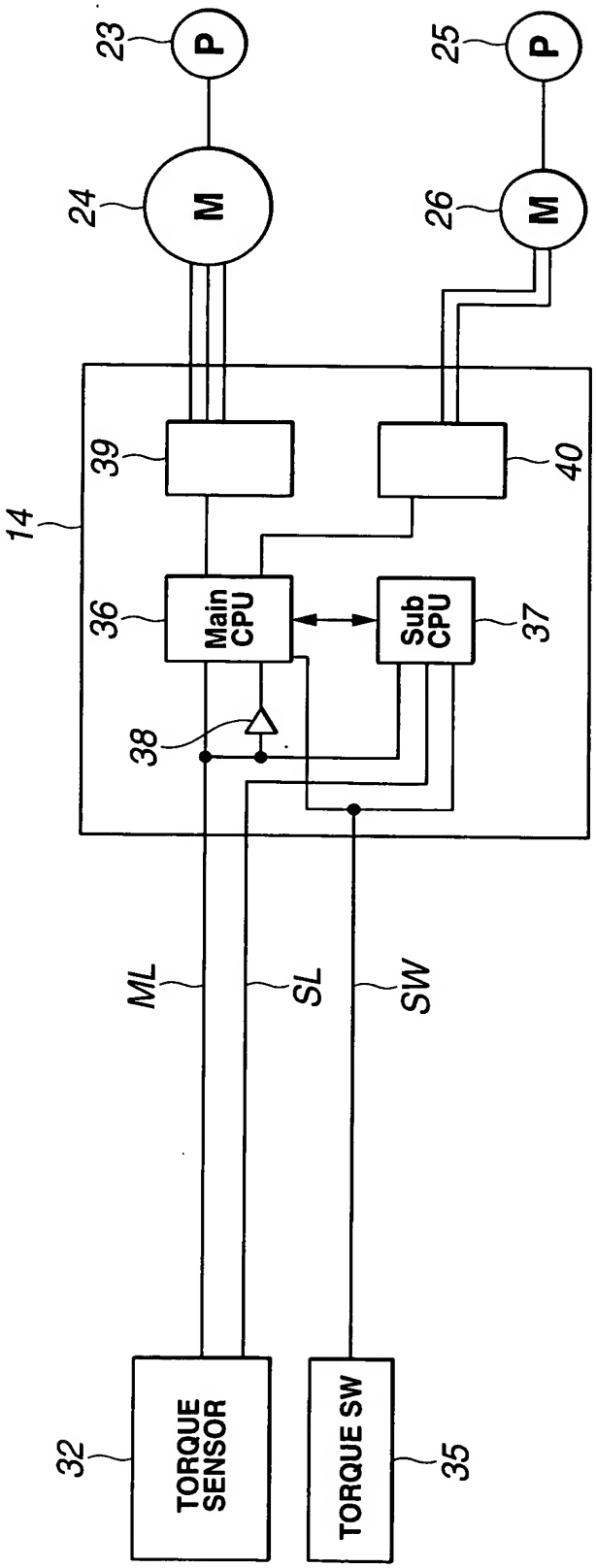
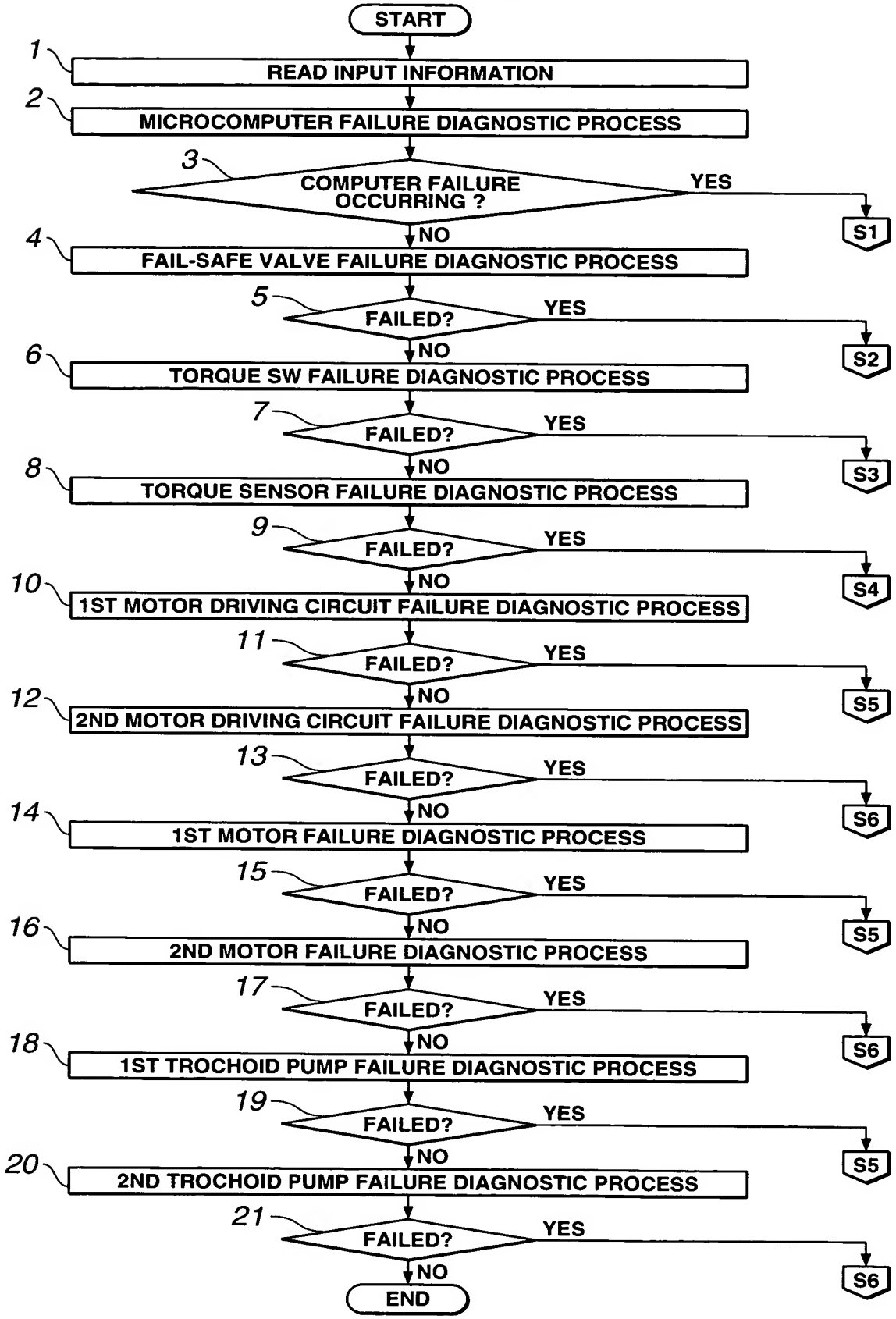


FIG.2


23
P
25
P
24
M
26
M
39
40
14
36
Main CPU
Sub CPU
37
38
ML
SL
SW
32
TORQUE SENSOR
TORQUE SW
35

# FIG.3


START
1
READ INPUT INFORMATION
2
MICROCOMPUTER FAILURE DIAGNOSTIC PROCESS
3
COMPUTER FAILURE OCCURRING ?
YES
S1
NO
4
FAIL-SAFE VALVE FAILURE DIAGNOSTIC PROCESS
5
FAILED?
YES
S2
NO
6
TORQUE SW FAILURE DIAGNOSTIC PROCESS
7
FAILED?
YES
S3
NO
8
TORQUE SENSOR FAILURE DIAGNOSTIC PROCESS
9
FAILED?
YES
S4
NO
10
1ST MOTOR DRIVING CIRCUIT FAILURE DIAGNOSTIC PROCESS
11
FAILED?
YES
S5
NO
12
2ND MOTOR DRIVING CIRCUIT FAILURE DIAGNOSTIC PROCESS
13
FAILED?
YES
S6
NO
14
1ST MOTOR FAILURE DIAGNOSTIC PROCESS
15
FAILED?
YES
S5
NO
16
2ND MOTOR FAILURE DIAGNOSTIC PROCESS
17
FAILED?
YES
S6
NO
18
1ST TROCHOID PUMP FAILURE DIAGNOSTIC PROCESS
19
FAILED?
YES
S5
NO
20
2ND TROCHOID PUMP FAILURE DIAGNOSTIC PROCESS
21
FAILED?
YES
S6
NO
END

# FIG.4

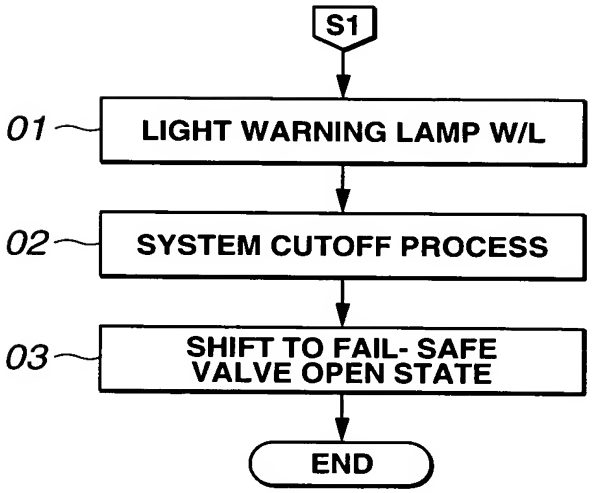
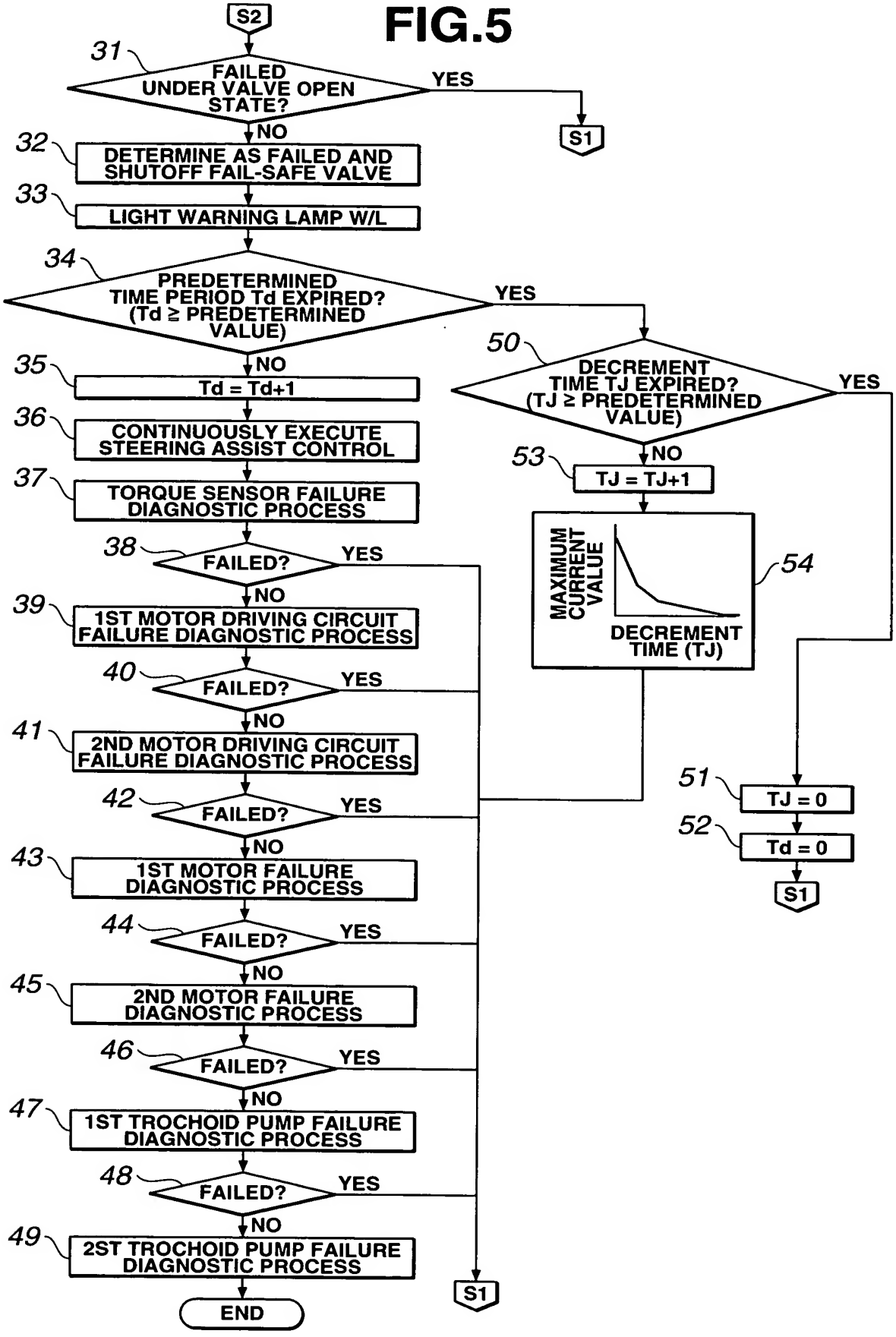
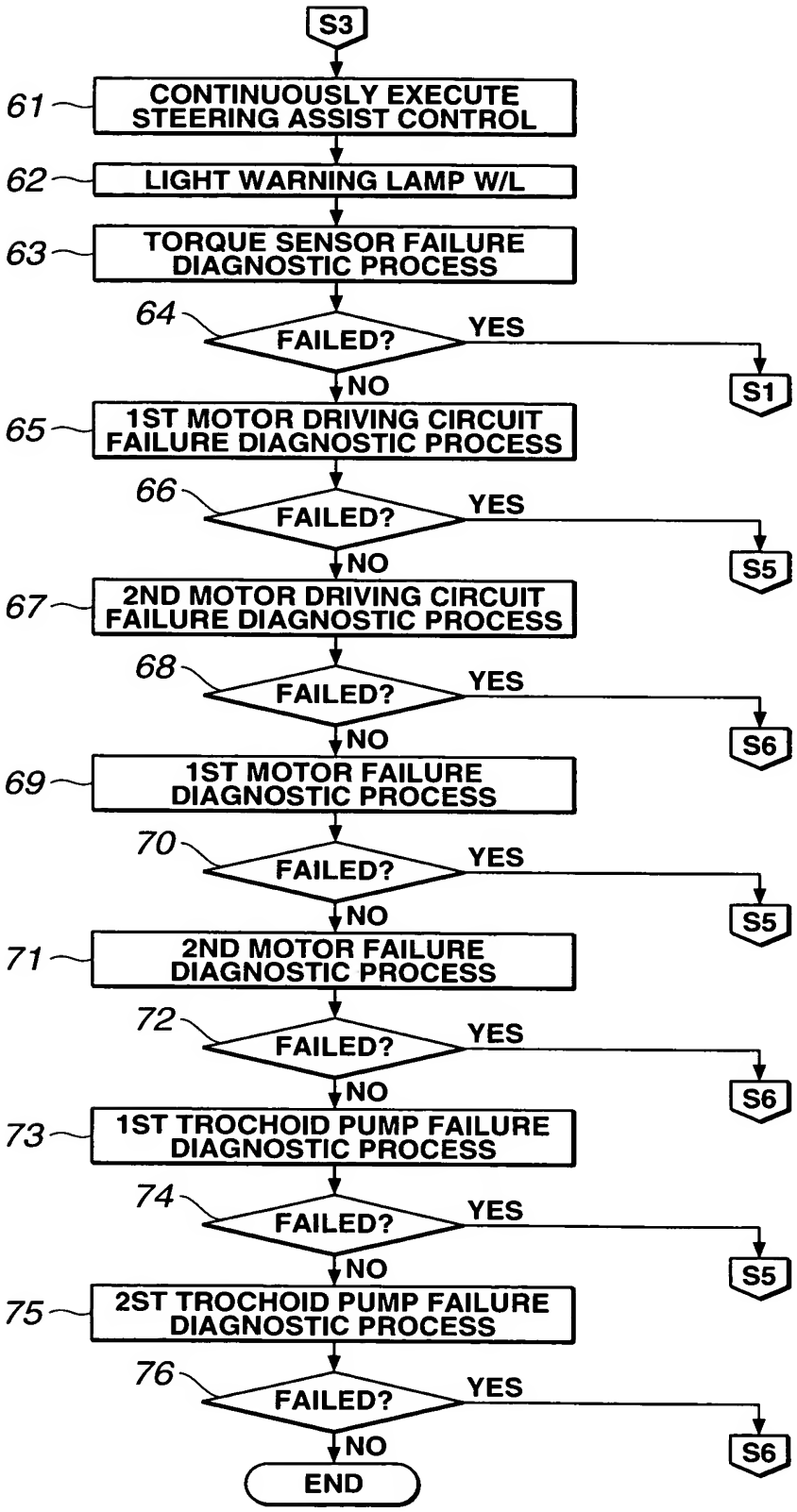

S1
01
LIGHT WARNING LAMP W/L
02
SYSTEM CUTOFF PROCESS
03
SHIFT TO FAIL- SAFE
VALVE OPEN STATE
END

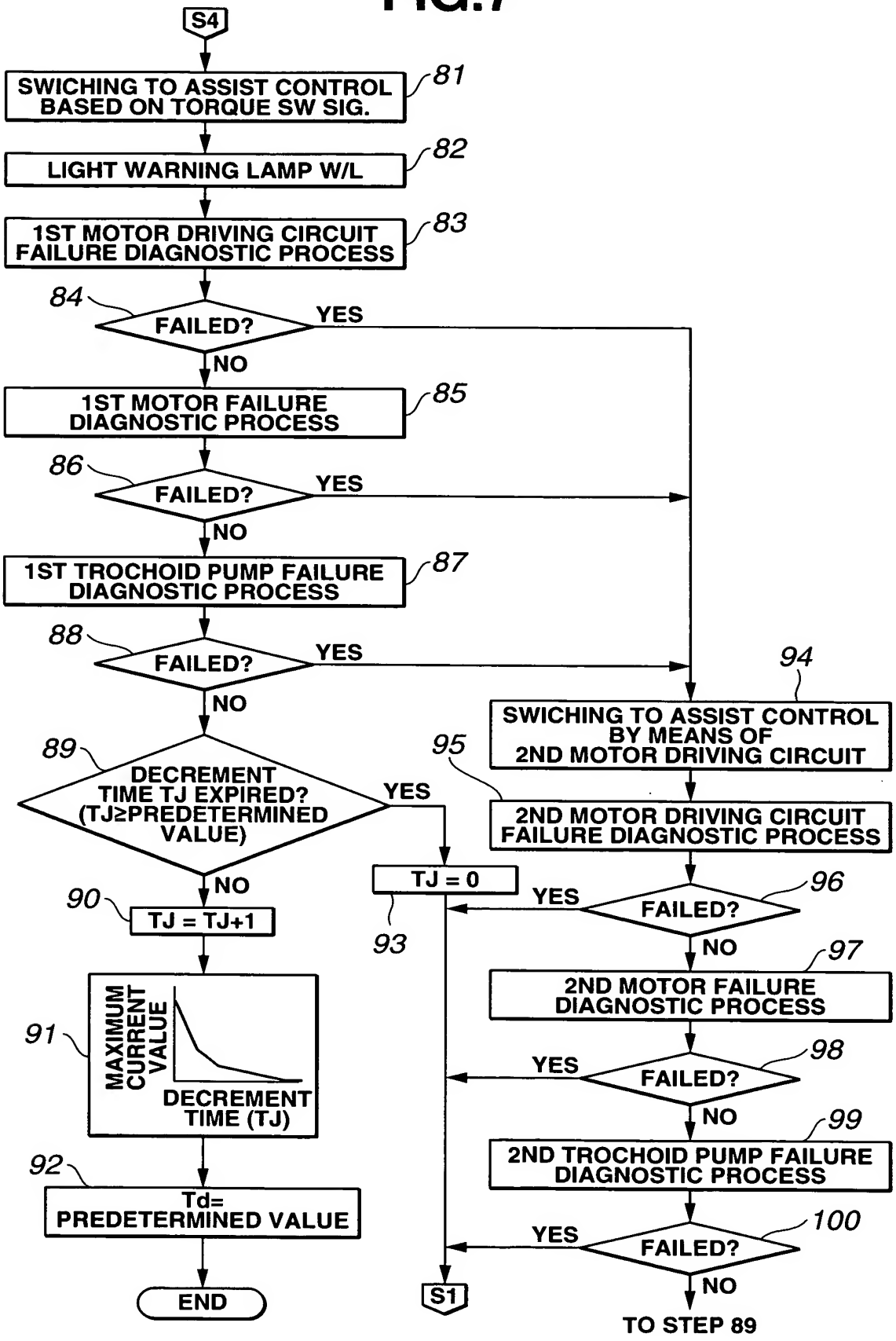
FIG.5


S2
31
FAILED UNDER VALVE OPEN STATE?
YES
S1
NO
32
DETERMINE AS FAILED AND SHUTOFF FAIL-SAFE VALVE
33
LIGHT WARNING LAMP W/L
34
PREDETERMINED TIME PERIOD Td EXPIRED? (Td ≥ PREDETERMINED VALUE)
YES
NO
35
Td = Td+1
36
CONTINUOUSLY EXECUTE STEERING ASSIST CONTROL
37
TORQUE SENSOR FAILURE DIAGNOSTIC PROCESS
38
FAILED?
YES
NO
39
1ST MOTOR DRIVING CIRCUIT FAILURE DIAGNOSTIC PROCESS
40
FAILED?
YES
NO
41
2ND MOTOR DRIVING CIRCUIT FAILURE DIAGNOSTIC PROCESS
42
FAILED?
YES
NO
43
1ST MOTOR FAILURE DIAGNOSTIC PROCESS
44
FAILED?
YES
NO
45
2ND MOTOR FAILURE DIAGNOSTIC PROCESS
46
FAILED?
YES
NO
47
1ST TROCHOID PUMP FAILURE DIAGNOSTIC PROCESS
48
FAILED?
YES
NO
49
2ST TROCHOID PUMP FAILURE DIAGNOSTIC PROCESS
S1
END
50
DECREMENT TIME TJ EXPIRED? (TJ ≥ PREDETERMINED VALUE)
YES
NO
53
TJ = TJ+1
MAXIMUM CURRENT VALUE
DECREMENT TIME (TJ)
54
51
TJ = 0
52
Td = 0
S1

# FIG.6


S3
61
CONTINUOUSLY EXECUTE STEERING ASSIST CONTROL
62
LIGHT WARNING LAMP W/L
63
TORQUE SENSOR FAILURE DIAGNOSTIC PROCESS
64
FAILED?
YES
S1
NO
65
1ST MOTOR DRIVING CIRCUIT FAILURE DIAGNOSTIC PROCESS
66
FAILED?
YES
S5
NO
67
2ND MOTOR DRIVING CIRCUIT FAILURE DIAGNOSTIC PROCESS
68
FAILED?
YES
S6
NO
69
1ST MOTOR FAILURE DIAGNOSTIC PROCESS
70
FAILED?
YES
S5
NO
71
2ND MOTOR FAILURE DIAGNOSTIC PROCESS
72
FAILED?
YES
S6
NO
73
1ST TROCHOID PUMP FAILURE DIAGNOSTIC PROCESS
74
FAILED?
YES
S5
NO
75
2ST TROCHOID PUMP FAILURE DIAGNOSTIC PROCESS
76
FAILED?
YES
S6
NO
END

# FIG.7


S4
SWICHING TO ASSIST CONTROL BASED ON TORQUE SW SIG.
81
LIGHT WARNING LAMP W/L
82
1ST MOTOR DRIVING CIRCUIT FAILURE DIAGNOSTIC PROCESS
83
84
FAILED?
YES
NO
1ST MOTOR FAILURE DIAGNOSTIC PROCESS
85
86
FAILED?
YES
NO
1ST TROCHOID PUMP FAILURE DIAGNOSTIC PROCESS
87
88
FAILED?
YES
NO
89
DECREMENT TIME TJ EXPIRED? (TJ≥PREDETERMINED VALUE)
YES
NO
90
TJ = TJ+1
91
MAXIMUM CURRENT VALUE
DECREMENT TIME (TJ)
92
Td= PREDETERMINED VALUE
END
TJ = 0
93
94
SWICHING TO ASSIST CONTROL BY MEANS OF 2ND MOTOR DRIVING CIRCUIT
95
2ND MOTOR DRIVING CIRCUIT FAILURE DIAGNOSTIC PROCESS
96
FAILED?
YES
NO
97
2ND MOTOR FAILURE DIAGNOSTIC PROCESS
98
FAILED?
YES
NO
99
2ND TROCHOID PUMP FAILURE DIAGNOSTIC PROCESS
100
FAILED?
YES
NO
S1
TO STEP 89

# FIG.8

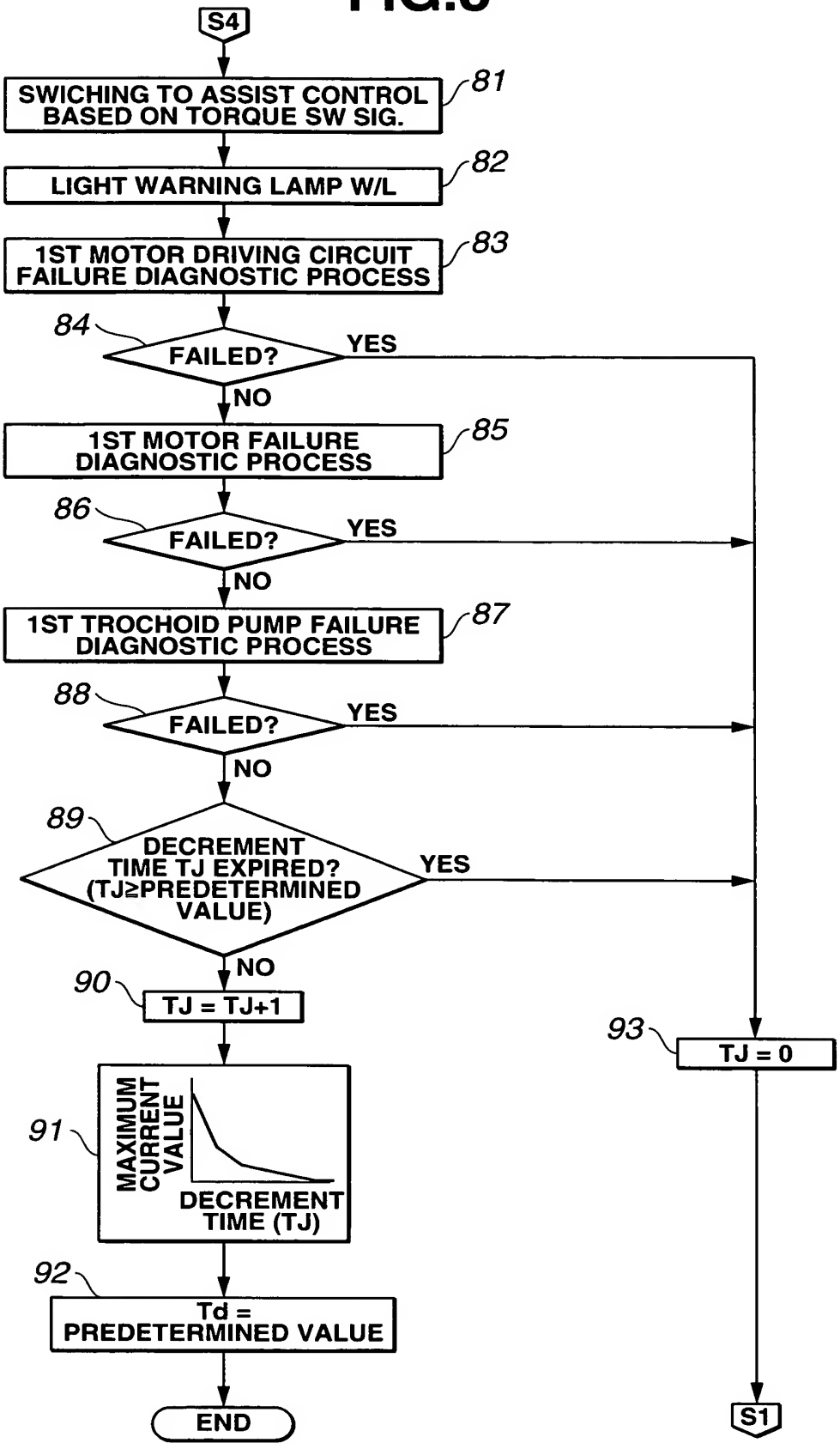
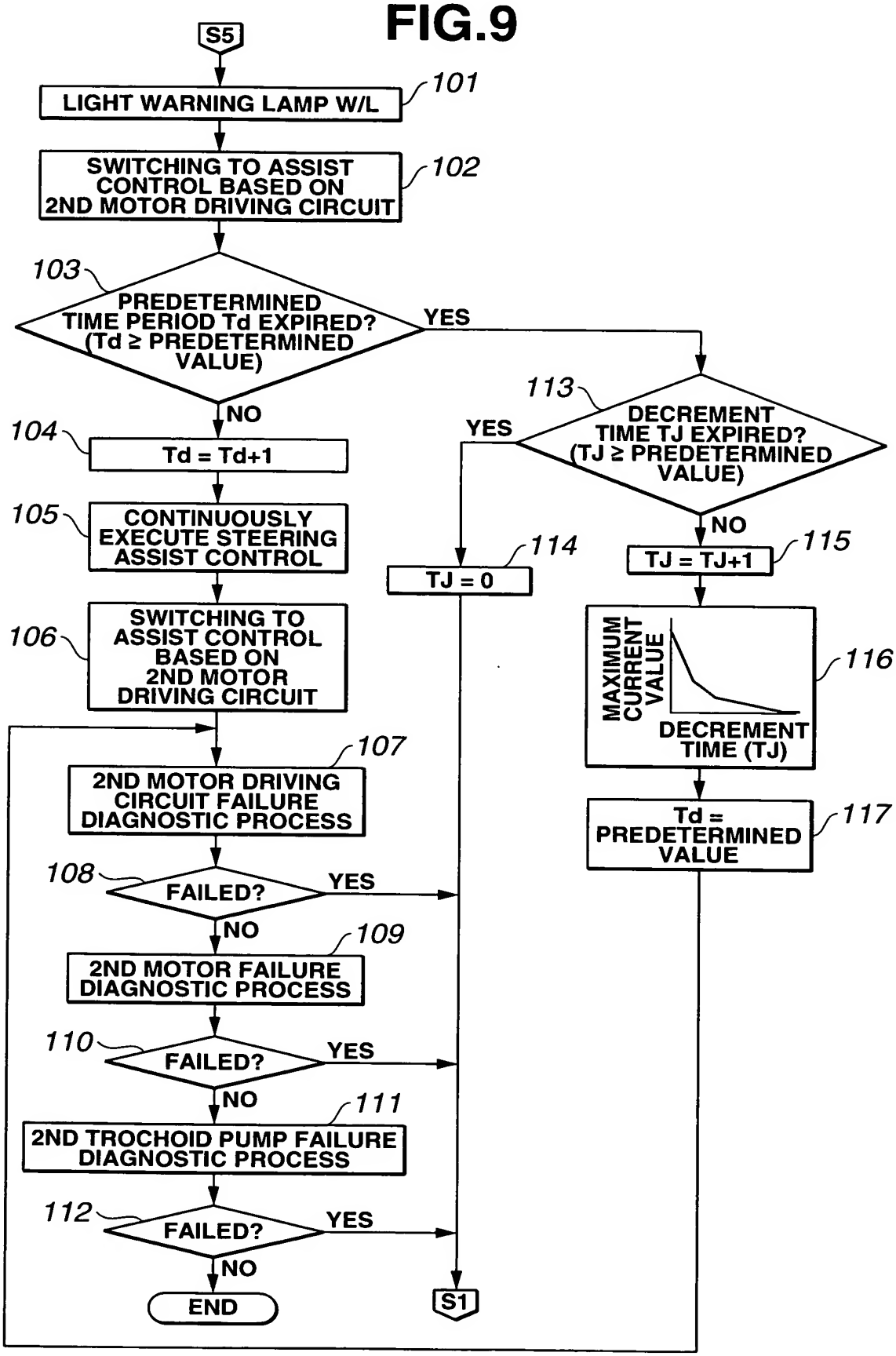
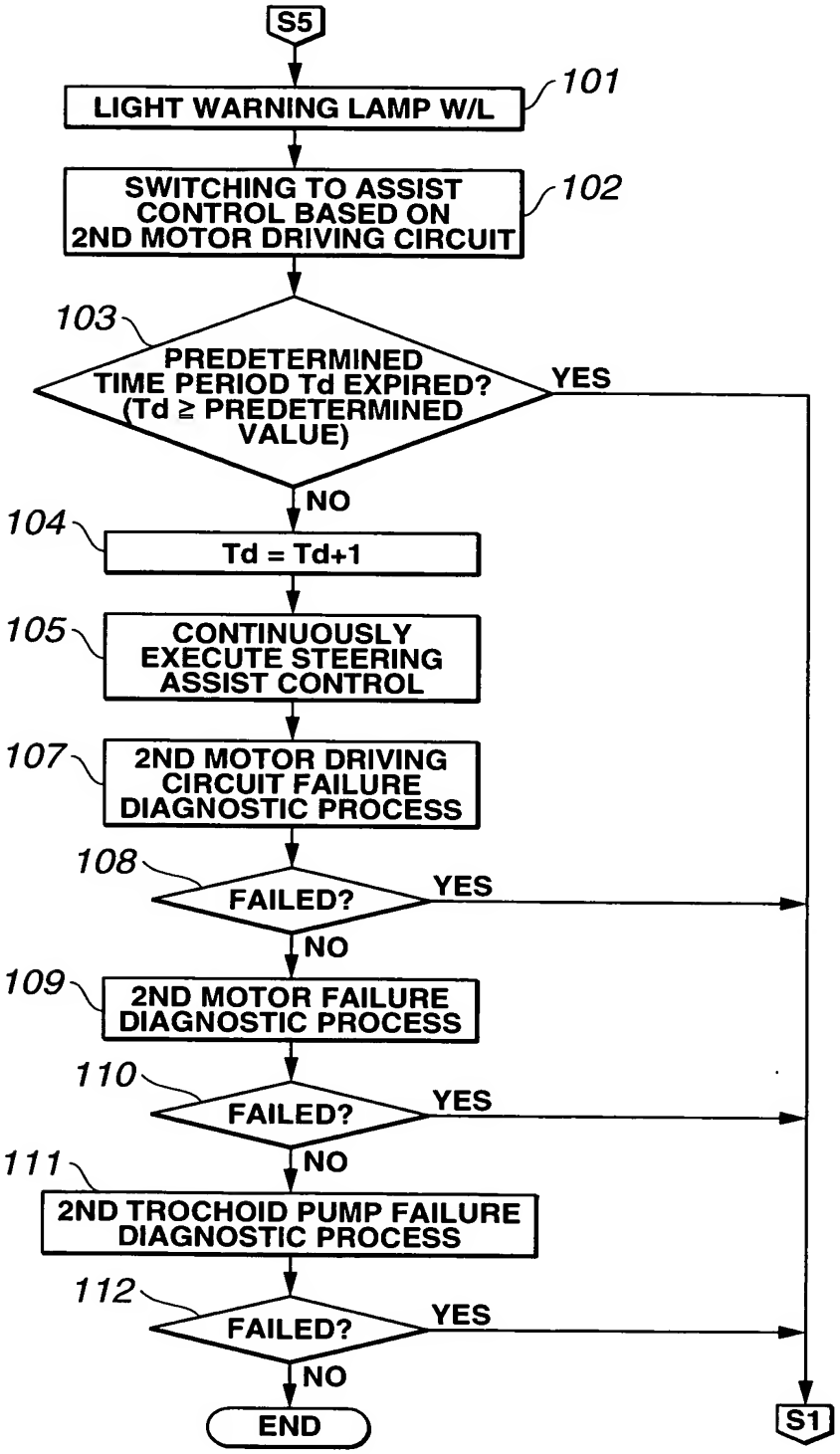

S4
SWICHING TO ASSIST CONTROL BASED ON TORQUE SW SIG.
81
LIGHT WARNING LAMP W/L
82
1ST MOTOR DRIVING CIRCUIT FAILURE DIAGNOSTIC PROCESS
83
84
FAILED?
YES
NO
1ST MOTOR FAILURE DIAGNOSTIC PROCESS
85
86
FAILED?
YES
NO
1ST TROCHOID PUMP FAILURE DIAGNOSTIC PROCESS
87
88
FAILED?
YES
NO
89
DECREMENT TIME TJ EXPIRED? (TJ≥PREDETERMINED VALUE)
YES
NO
90
TJ = TJ+1
91
MAXIMUM CURRENT VALUE
DECREMENT TIME (TJ)
92
Td = PREDETERMINED VALUE
END
93
TJ = 0
S1

FIG.9


S5
LIGHT WARNING LAMP W/L
101
SWITCHING TO ASSIST CONTROL BASED ON 2ND MOTOR DRIVING CIRCUIT
102
103
PREDETERMINED TIME PERIOD Td EXPIRED? (Td ≥ PREDETERMINED VALUE)
YES
NO
104
Td = Td+1
105
CONTINUOUSLY EXECUTE STEERING ASSIST CONTROL
106
SWITCHING TO ASSIST CONTROL BASED ON 2ND MOTOR DRIVING CIRCUIT
107
2ND MOTOR DRIVING CIRCUIT FAILURE DIAGNOSTIC PROCESS
108
FAILED?
YES
NO
109
2ND MOTOR FAILURE DIAGNOSTIC PROCESS
110
FAILED?
YES
NO
111
2ND TROCHOID PUMP FAILURE DIAGNOSTIC PROCESS
112
FAILED?
YES
NO
END
S1
113
DECREMENT TIME TJ EXPIRED? (TJ ≥ PREDETERMINED VALUE)
YES
NO
114
TJ = 0
115
TJ = TJ+1
116
MAXIMUM CURRENT VALUE
DECREMENT TIME (TJ)
117
Td = PREDETERMINED VALUE

# FIG.10


S5
LIGHT WARNING LAMP W/L
101
SWITCHING TO ASSIST CONTROL BASED ON 2ND MOTOR DRIVING CIRCUIT
102
103
PREDETERMINED TIME PERIOD Td EXPIRED? (Td ≥ PREDETERMINED VALUE)
YES
NO
104
Td = Td+1
105
CONTINUOUSLY EXECUTE STEERING ASSIST CONTROL
107
2ND MOTOR DRIVING CIRCUIT FAILURE DIAGNOSTIC PROCESS
108
FAILED?
YES
NO
109
2ND MOTOR FAILURE DIAGNOSTIC PROCESS
110
FAILED?
YES
NO
111
2ND TROCHOID PUMP FAILURE DIAGNOSTIC PROCESS
112
FAILED?
YES
NO
END
S1

# FIG.11

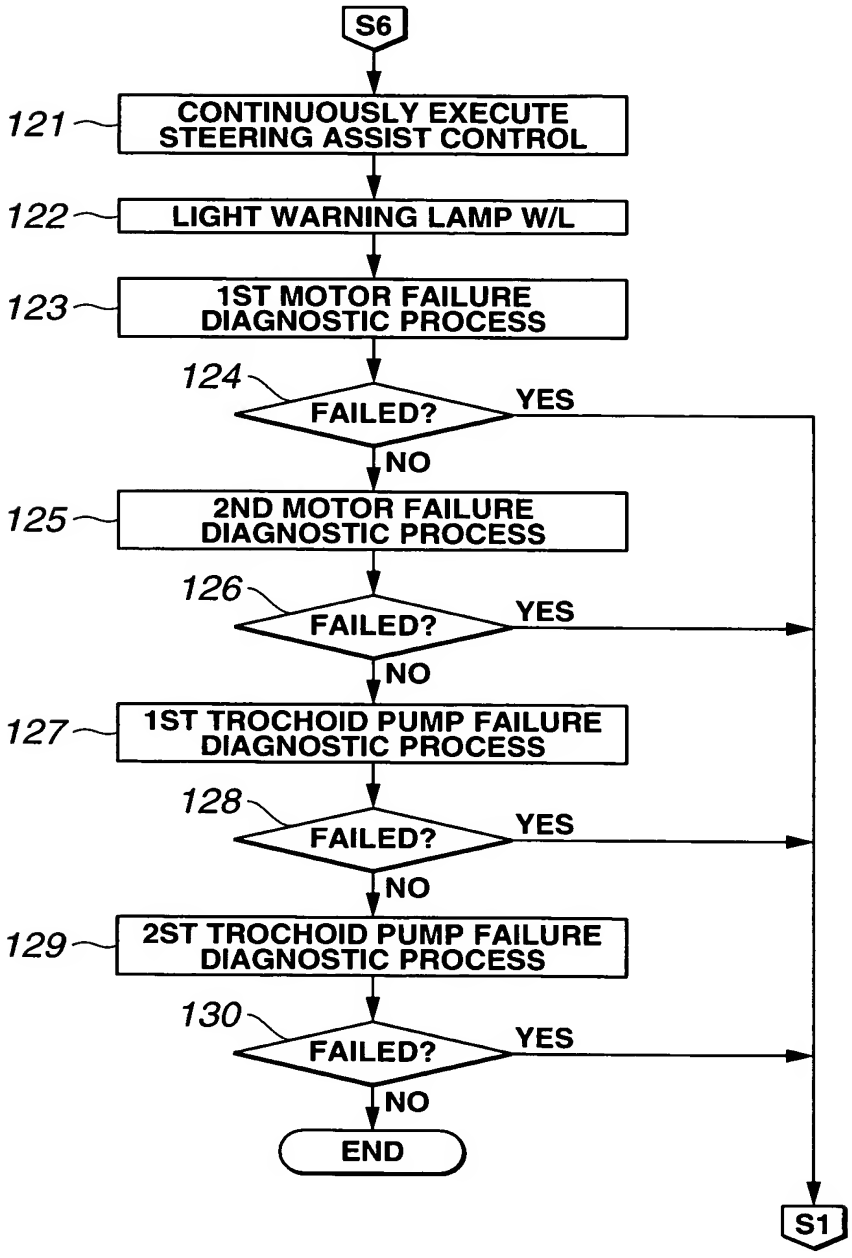
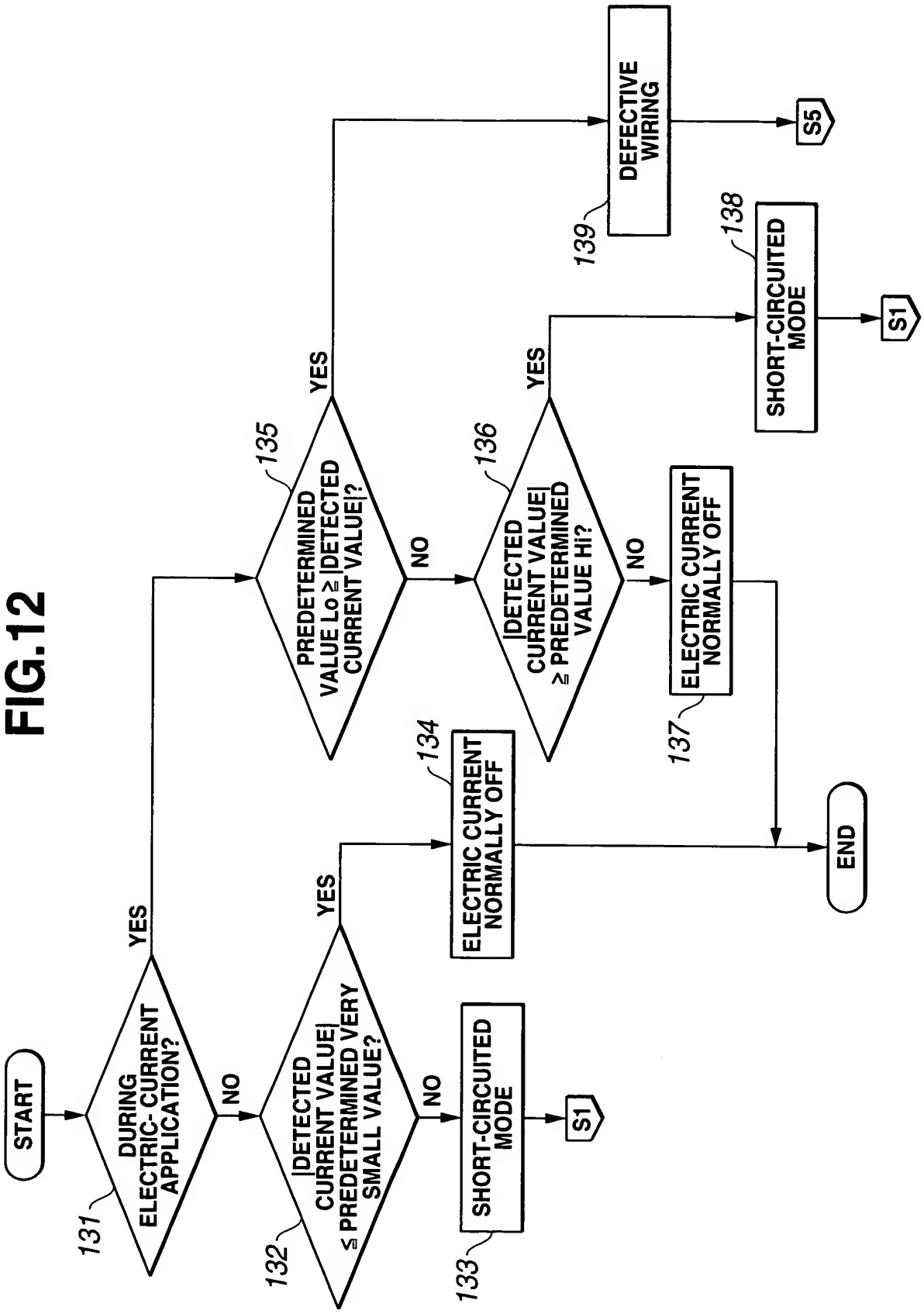
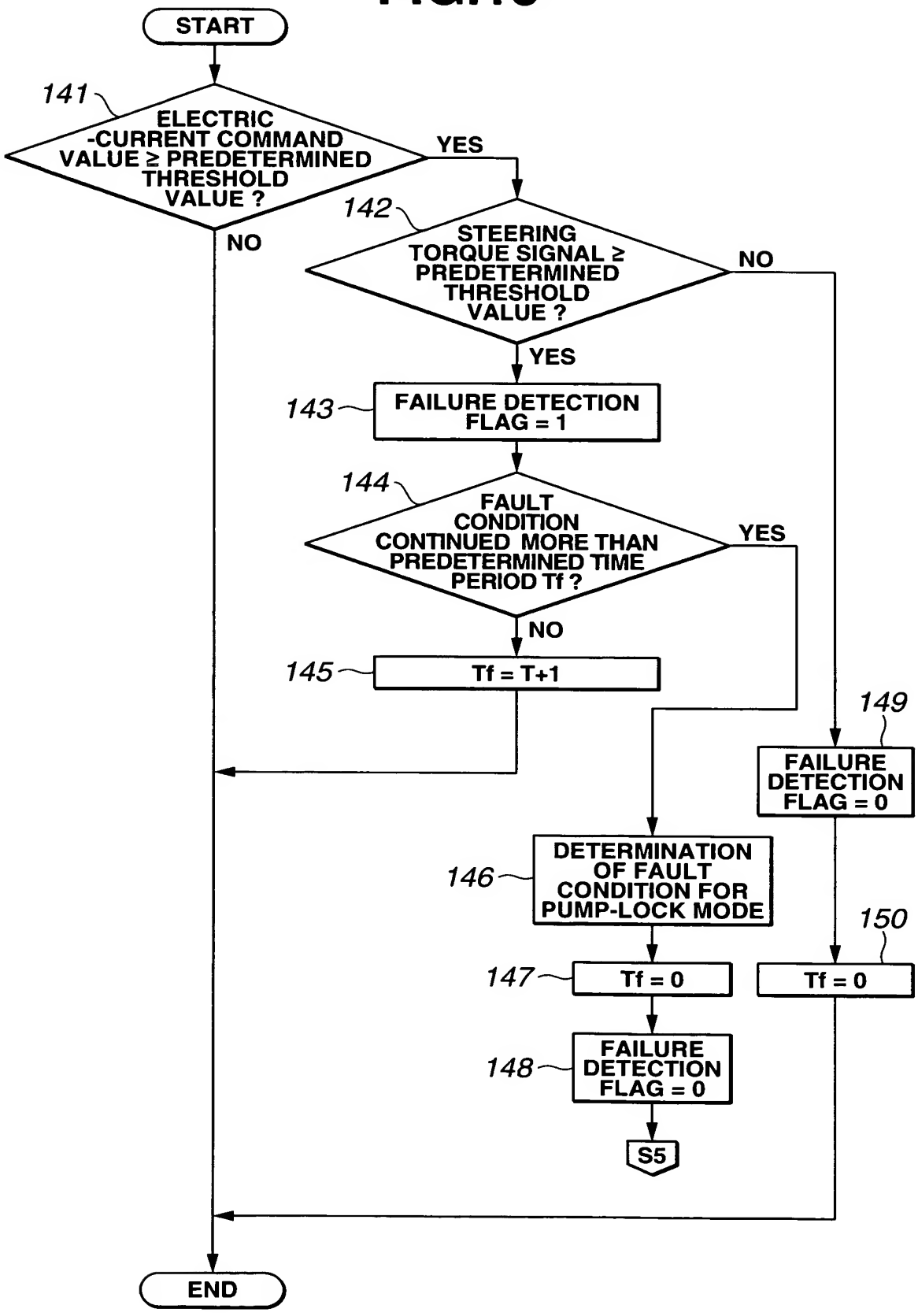

S6
121
CONTINUOUSLY EXECUTE STEERING ASSIST CONTROL
122
LIGHT WARNING LAMP W/L
123
1ST MOTOR FAILURE DIAGNOSTIC PROCESS
124
FAILED?
YES
NO
125
2ND MOTOR FAILURE DIAGNOSTIC PROCESS
126
FAILED?
YES
NO
127
1ST TROCHOID PUMP FAILURE DIAGNOSTIC PROCESS
128
FAILED?
YES
NO
129
2ST TROCHOID PUMP FAILURE DIAGNOSTIC PROCESS
130
FAILED?
YES
NO
END
S1

FIG.12


START
DURING ELECTRIC-CURRENT APPLICATION?
131
YES
NO
|DETECTED CURRENT VALUE| ≦ PREDETERMINED VERY SMALL VALUE?
132
YES
NO
SHORT-CIRCUITED MODE
133
S1
ELECTRIC CURRENT NORMALLY OFF
134
PREDETERMINED VALUE Lo ≧ |DETECTED CURRENT VALUE|?
135
YES
NO
|DETECTED CURRENT VALUE| ≧ PREDETERMINED VALUE Hi?
136
YES
NO
ELECTRIC CURRENT NORMALLY OFF
137
SHORT-CIRCUITED MODE
138
S1
DEFECTIVE WIRING
139
S5
END

# FIG.13


START
141
ELECTRIC -CURRENT COMMAND VALUE ≥ PREDETERMINED THRESHOLD VALUE ?
YES
NO
142
STEERING TORQUE SIGNAL ≥ PREDETERMINED THRESHOLD VALUE ?
NO
YES
143
FAILURE DETECTION FLAG = 1
144
FAULT CONDITION CONTINUED MORE THAN PREDETERMINED TIME PERIOD Tf ?
YES
NO
145
Tf = T+1
149
FAILURE DETECTION FLAG = 0
146
DETERMINATION OF FAULT CONDITION FOR PUMP-LOCK MODE
150
147
Tf = 0
Tf = 0
148
FAILURE DETECTION FLAG = 0
S5
END

# FIG.14

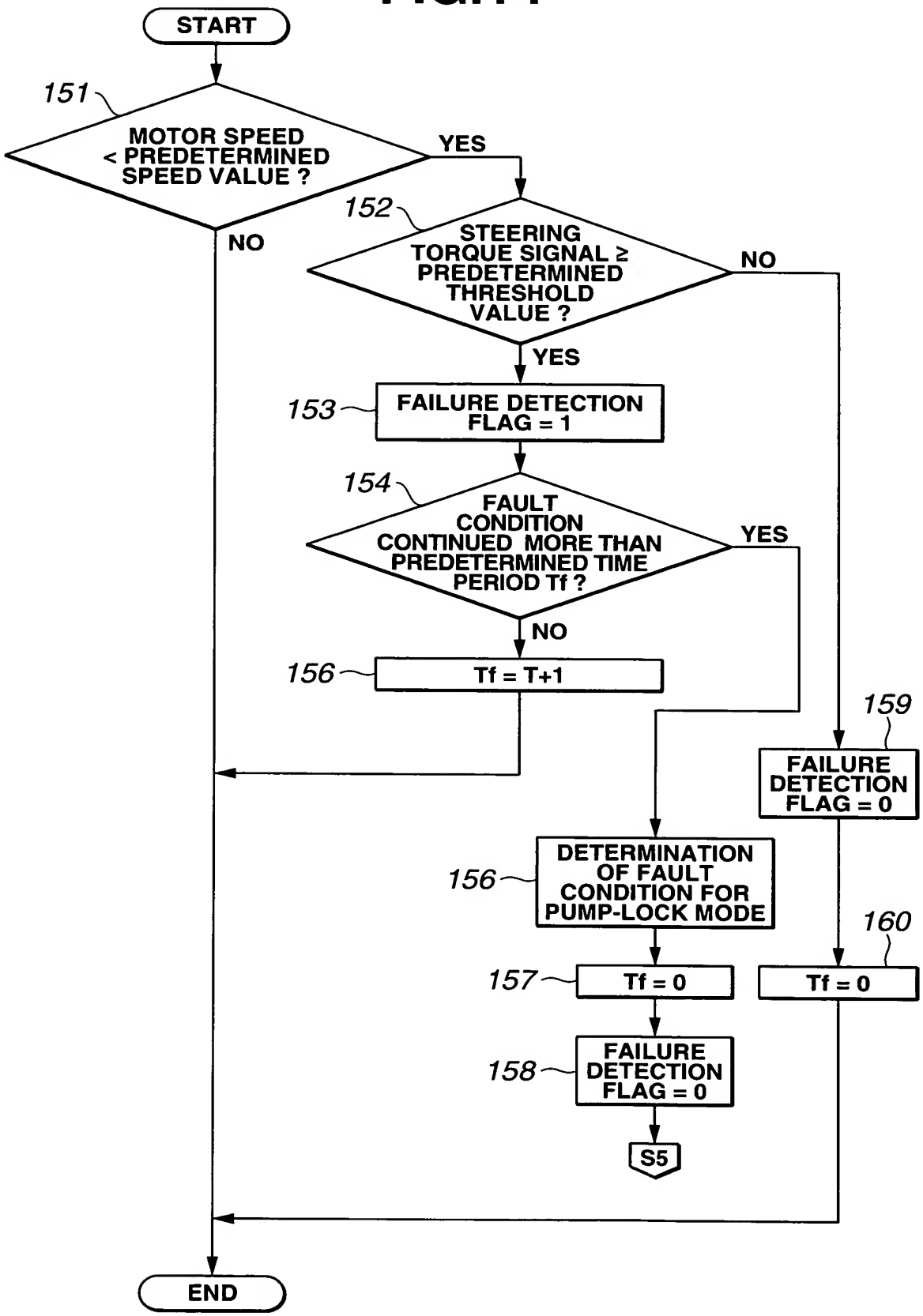
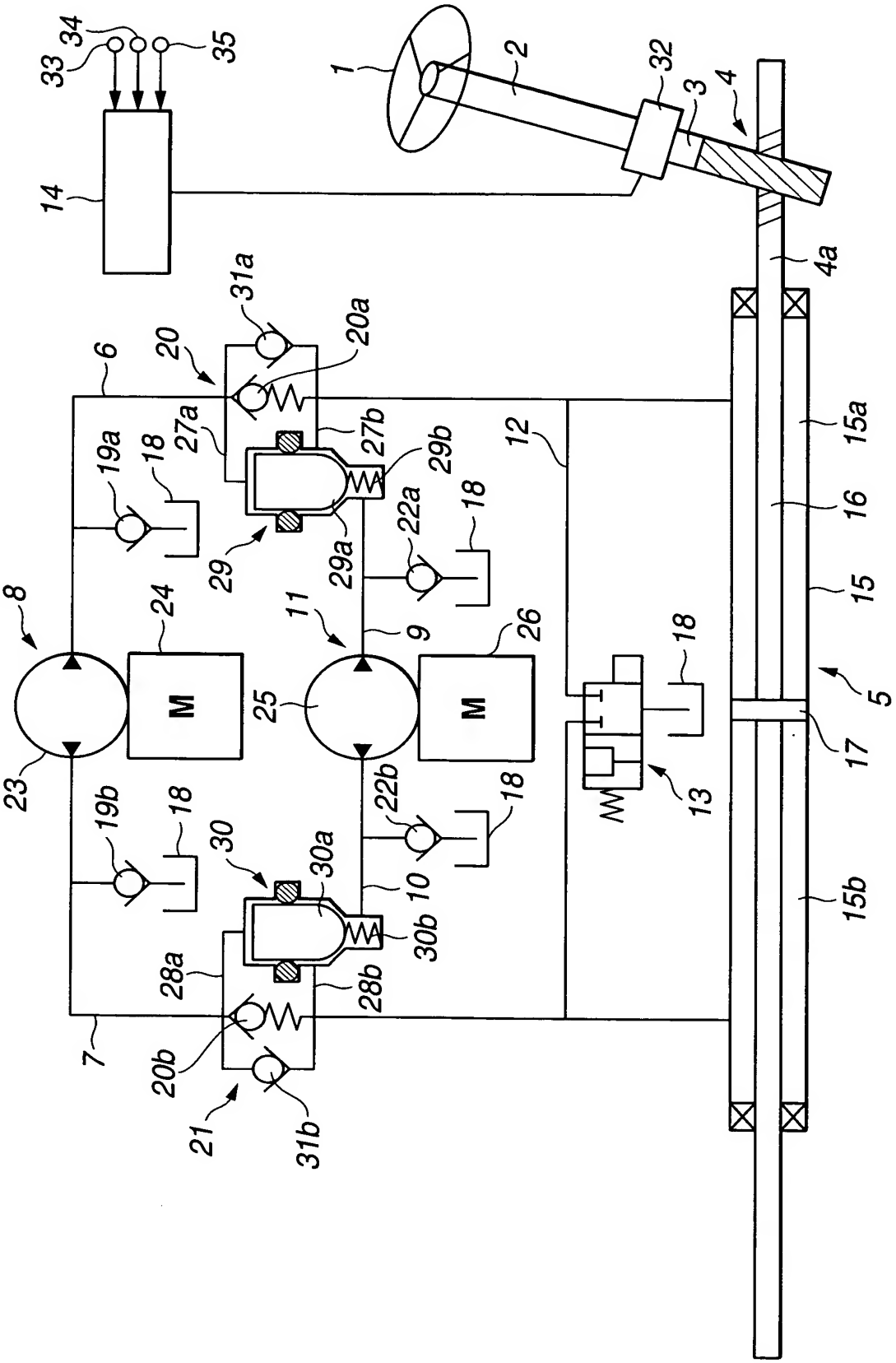

START
151
MOTOR SPEED < PREDETERMINED SPEED VALUE ?
YES
NO
152
STEERING TORQUE SIGNAL ≥ PREDETERMINED THRESHOLD VALUE ?
NO
YES
153
FAILURE DETECTION FLAG = 1
154
FAULT CONDITION CONTINUED MORE THAN PREDETERMINED TIME PERIOD Tf ?
YES
NO
156
Tf = T+1
159
FAILURE DETECTION FLAG = 0
156
DETERMINATION OF FAULT CONDITION FOR PUMP-LOCK MODE
160
157
Tf = 0
Tf = 0
158
FAILURE DETECTION FLAG = 0
S5
END

FIG.15


1
2
3
4
4a
5
6
7
8
9
10
11
12
13
14
15
15a
15b
16
17
18
19a
19b
20
20a
20b
21
22a
22b
23
24
25
26
27a
27b
28a
28b
29
29a
29b
30
30a
30b
31a
31b
32
33
34
35
M

# FIG.16

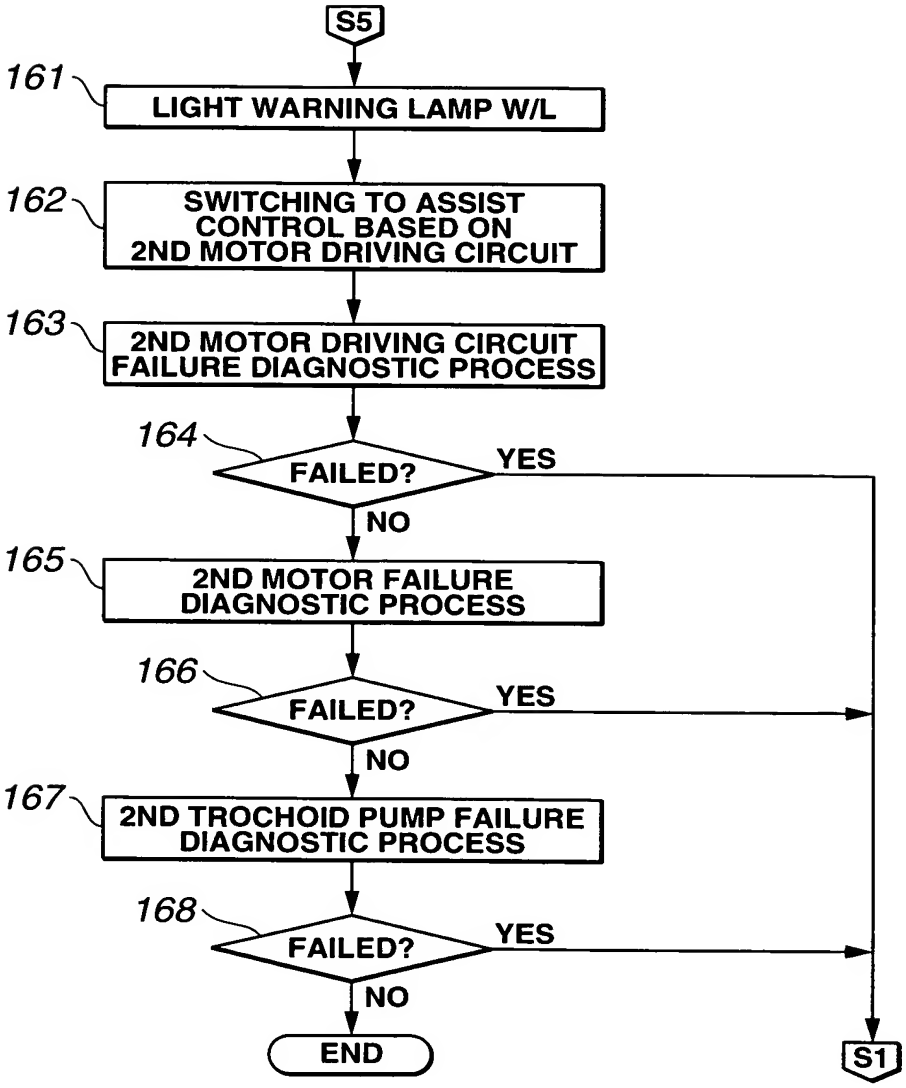

S5
161
LIGHT WARNING LAMP W/L
162
SWITCHING TO ASSIST CONTROL BASED ON 2ND MOTOR DRIVING CIRCUIT
163
2ND MOTOR DRIVING CIRCUIT FAILURE DIAGNOSTIC PROCESS
164
FAILED?
YES
NO
165
2ND MOTOR FAILURE DIAGNOSTIC PROCESS
166
FAILED?
YES
NO
167
2ND TROCHOID PUMP FAILURE DIAGNOSTIC PROCESS
168
FAILED?
YES
NO
END
S1

FIG.17

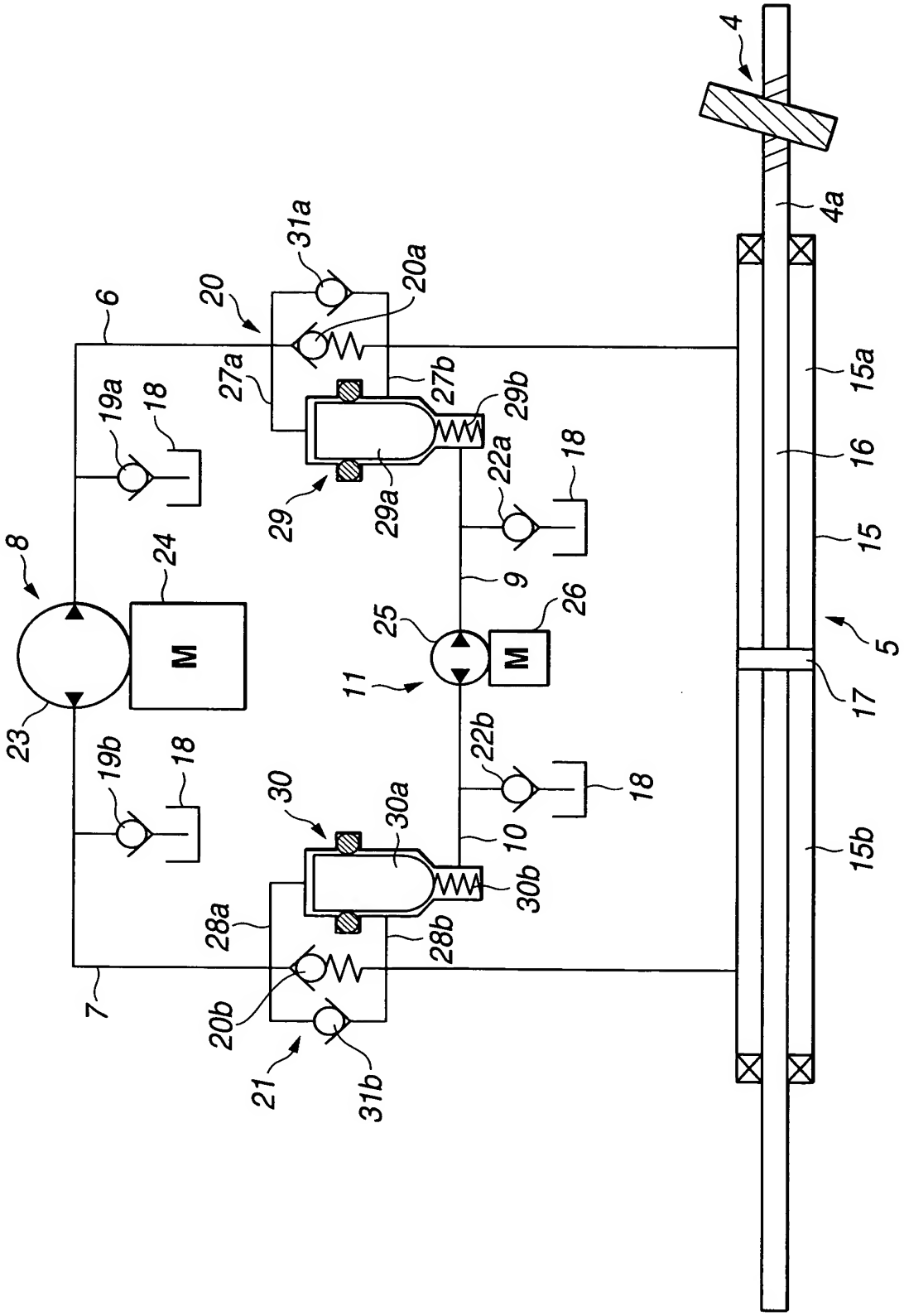

4
4a
15a
16
15
5
17
15b
6
20
31a
20a
27a
27b
29b
19a
18
29
29a
22a
18
8
24
9
25
26
M
M
11
23
19b
18
22b
18
30
30a
10
30b
28a
28b
7
20b
21
31b

FIG.18

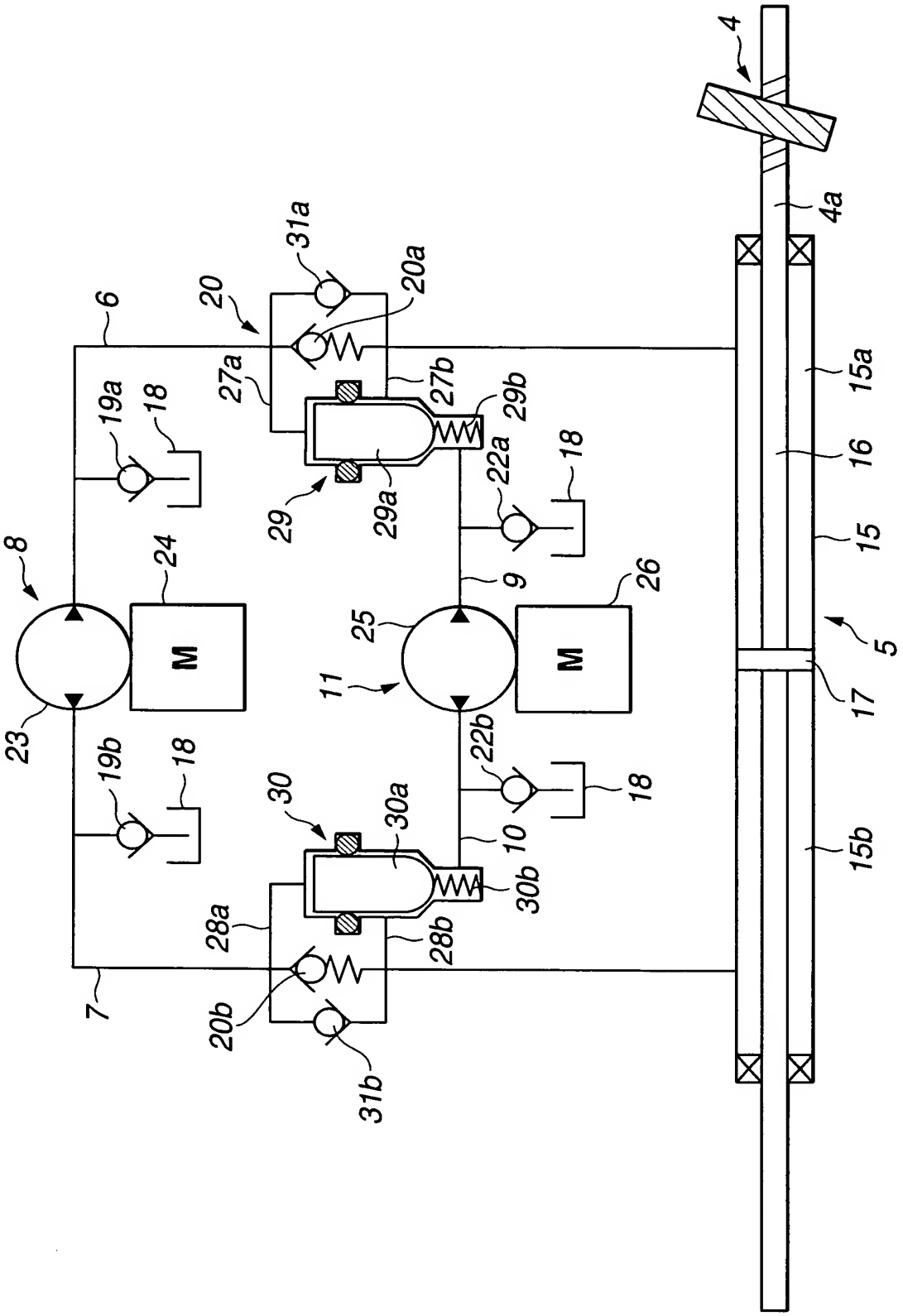

4
4a
15a
16
15
5
17
15b
6
20
31a
20a
27a
27b
29b
19a
18
29
29a
22a
8
24
9
26
25
M
11
23
22b
19b
30
30a
10
30b
28a
28b
7
20b
31b

FIG.19

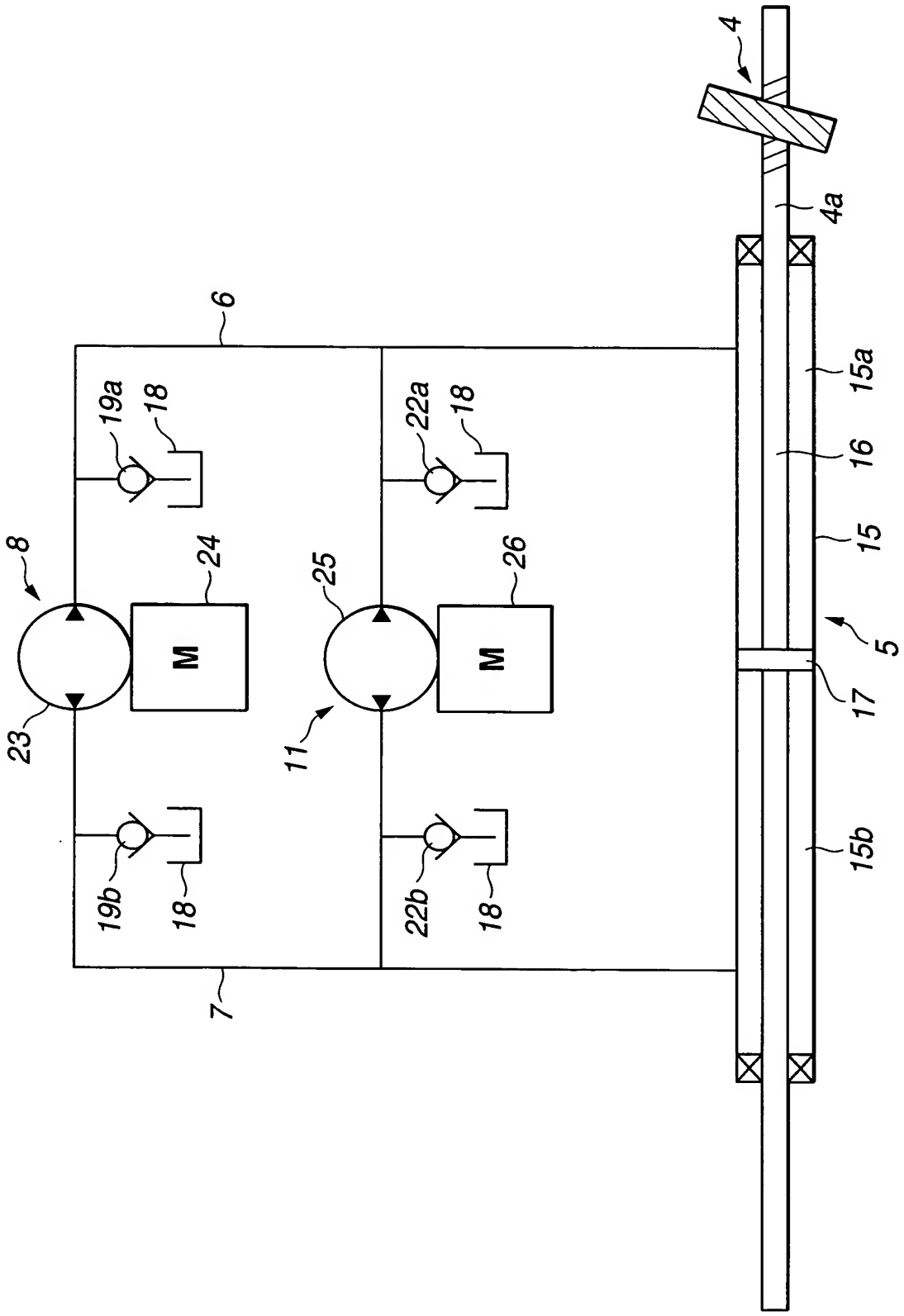
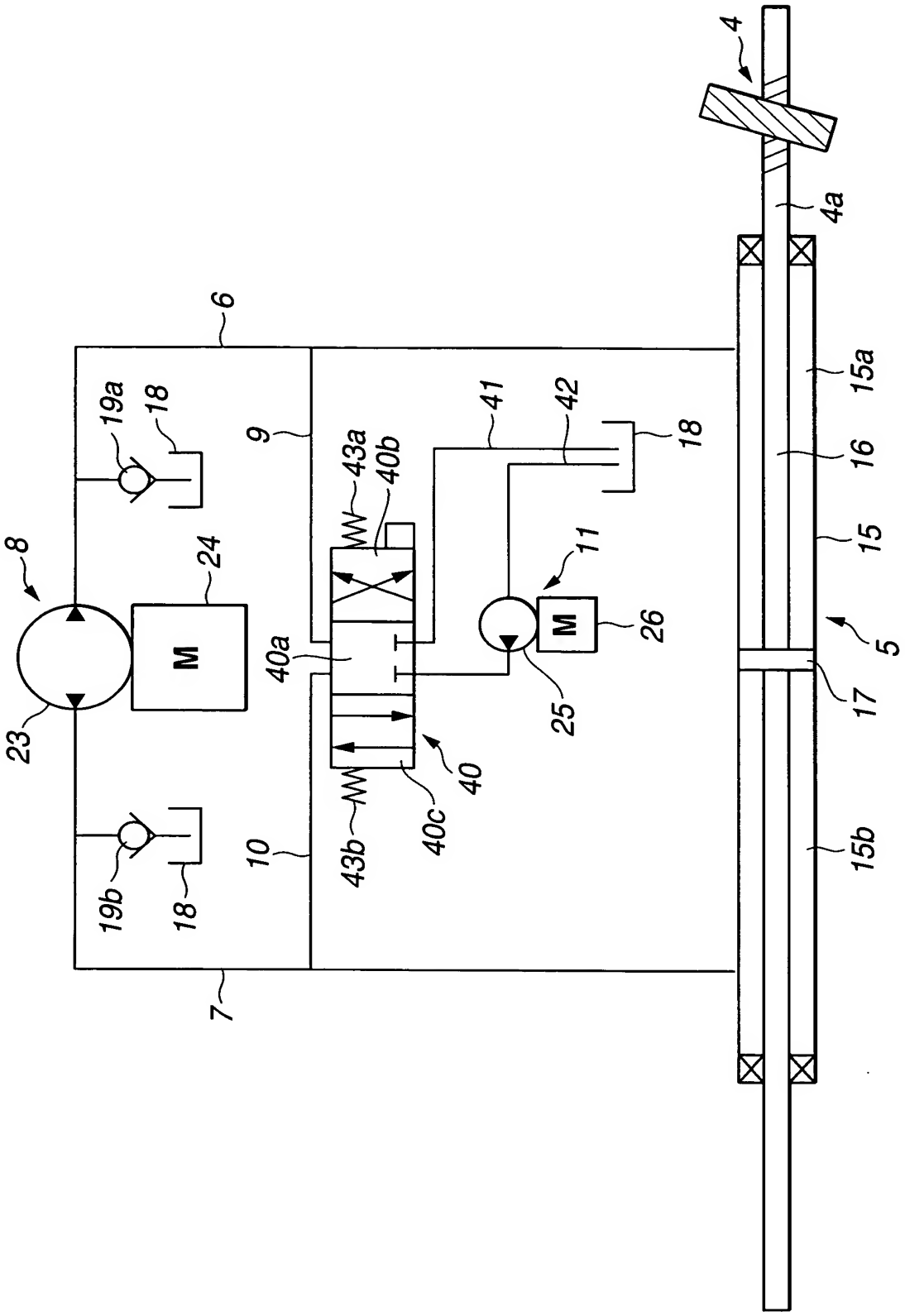

4
4a
6
15a
16
15
5
17
15b
19a
18
22a
18
8
24
25
26
M
M
23
11
19b
18
22b
18
7

FIG.20


4
4a
6
15a
16
15
5
17
15b
19a
18
9
43a
40b
41
42
18
8
24
M
11
M
26
40a
23
25
40
40c
43b
10
19b
18
7

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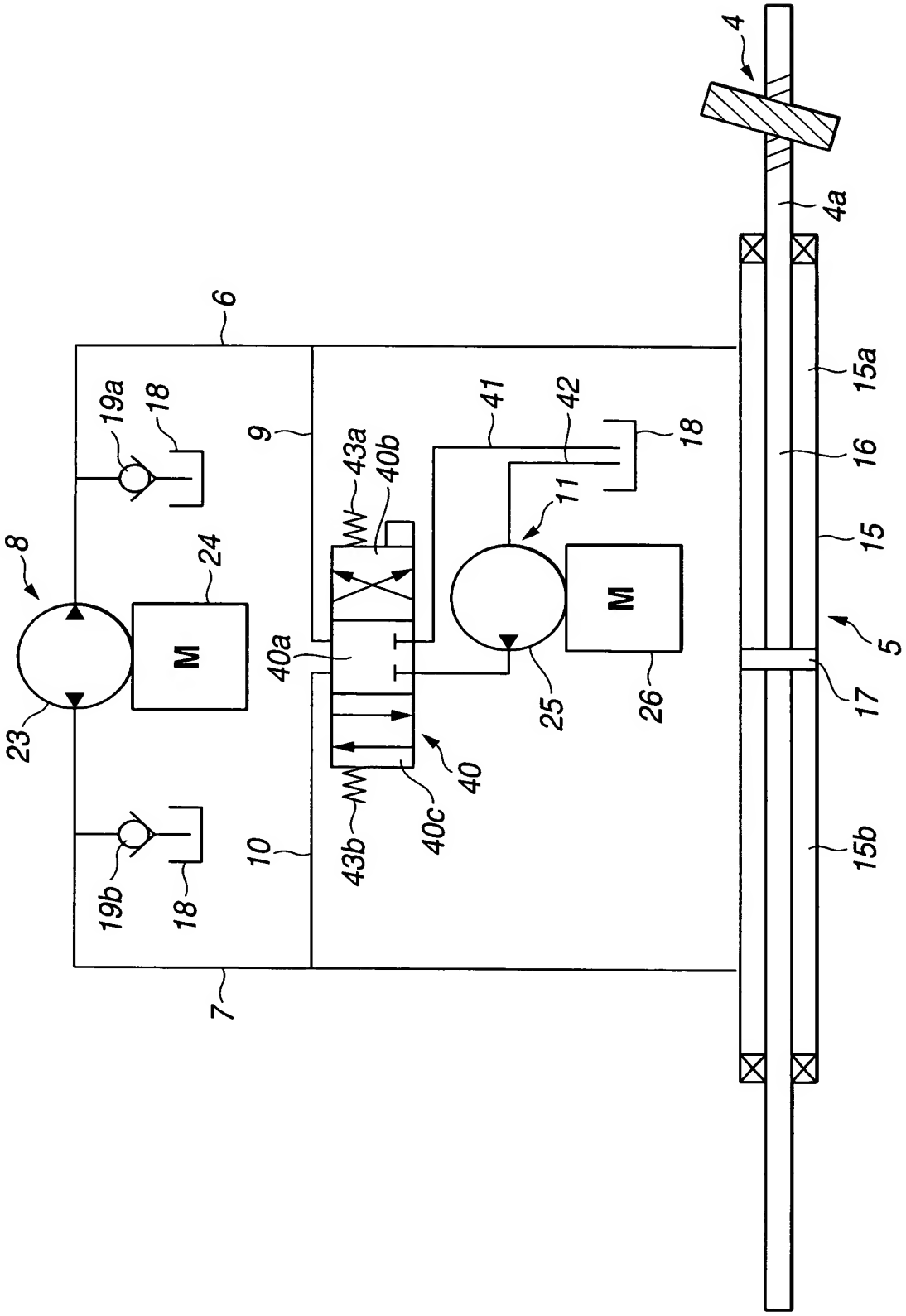
DOCKET NO.: 023484-0222

FIG.21



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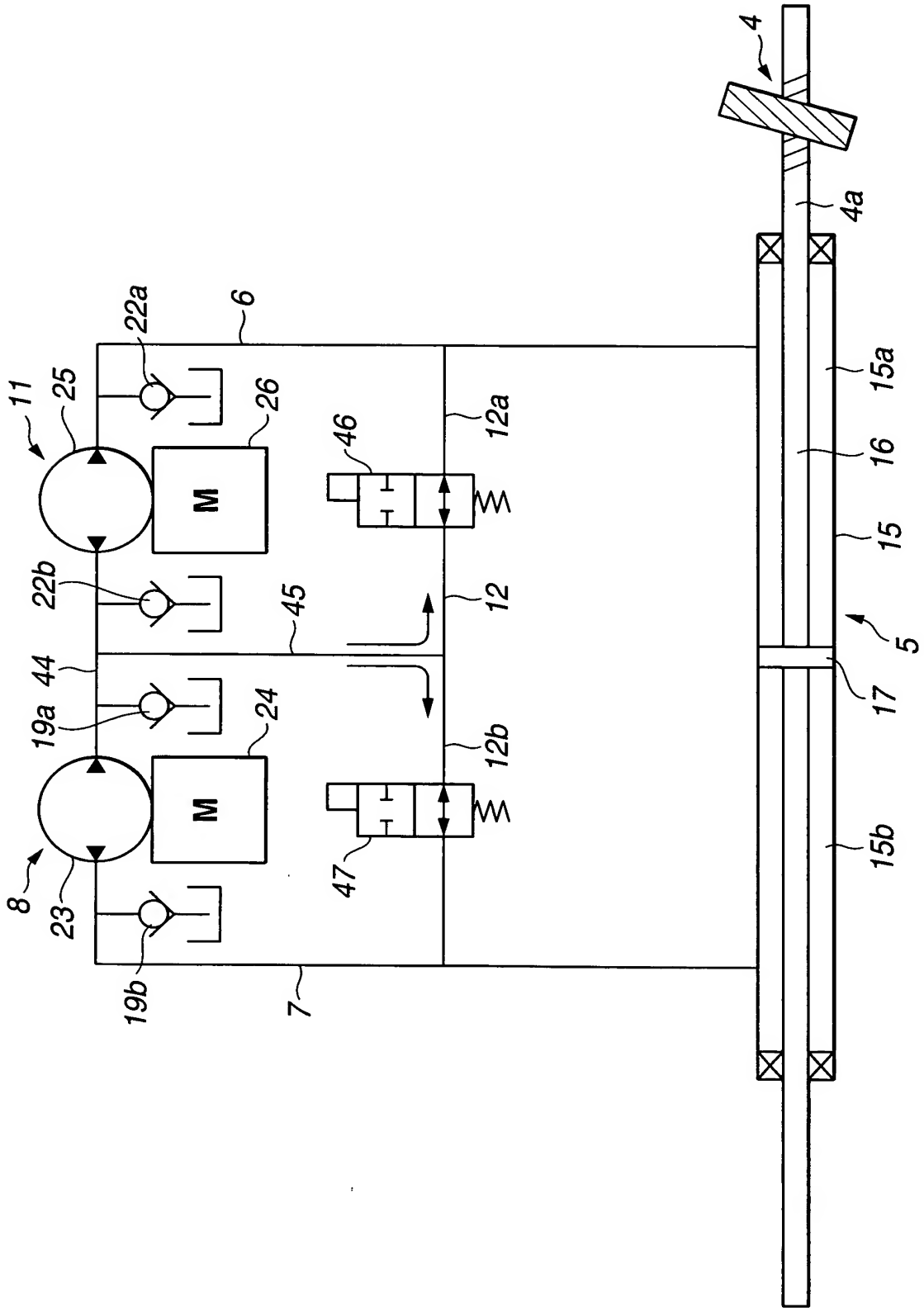
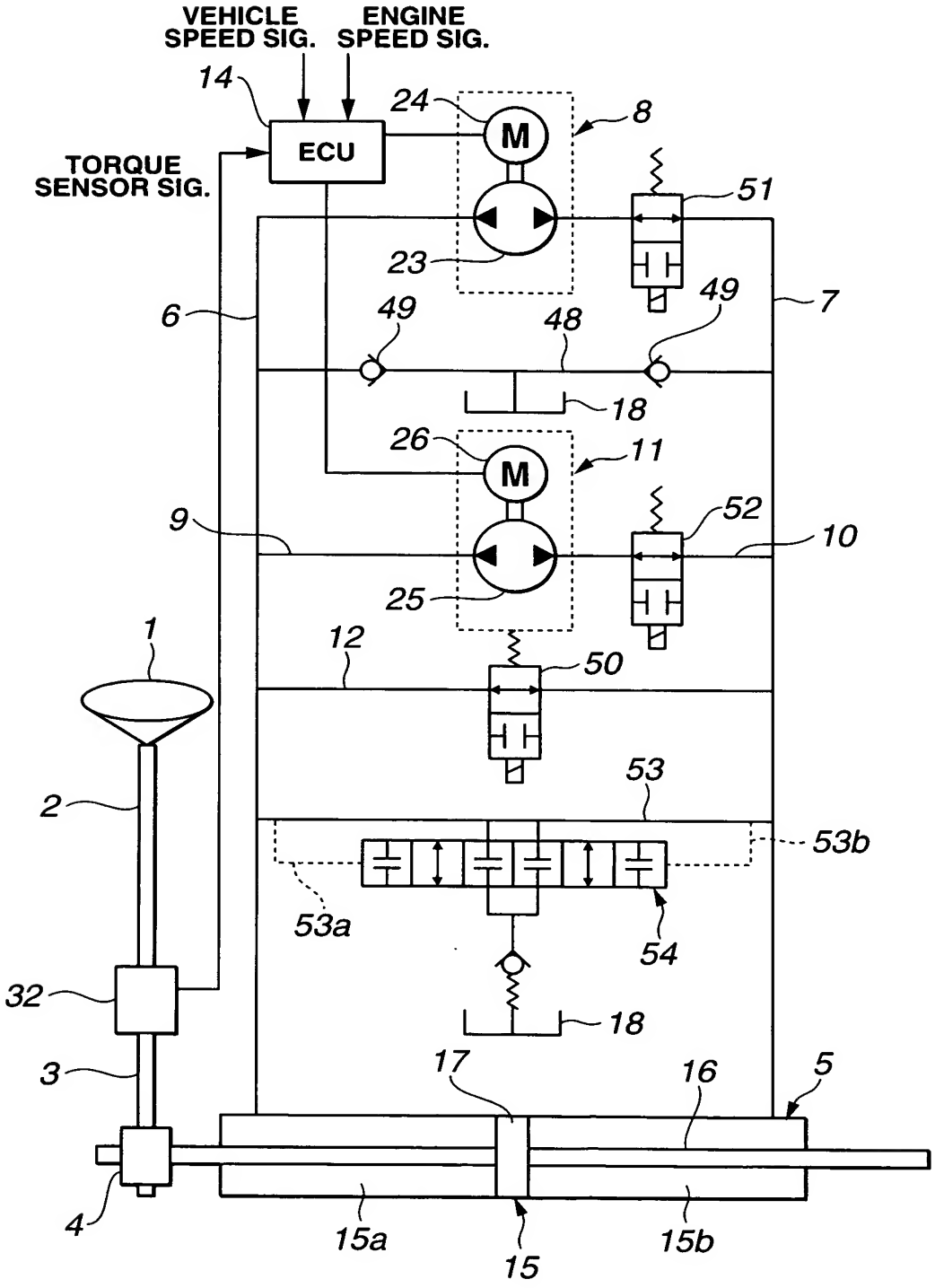
DOCKET NO.: 023484-0222

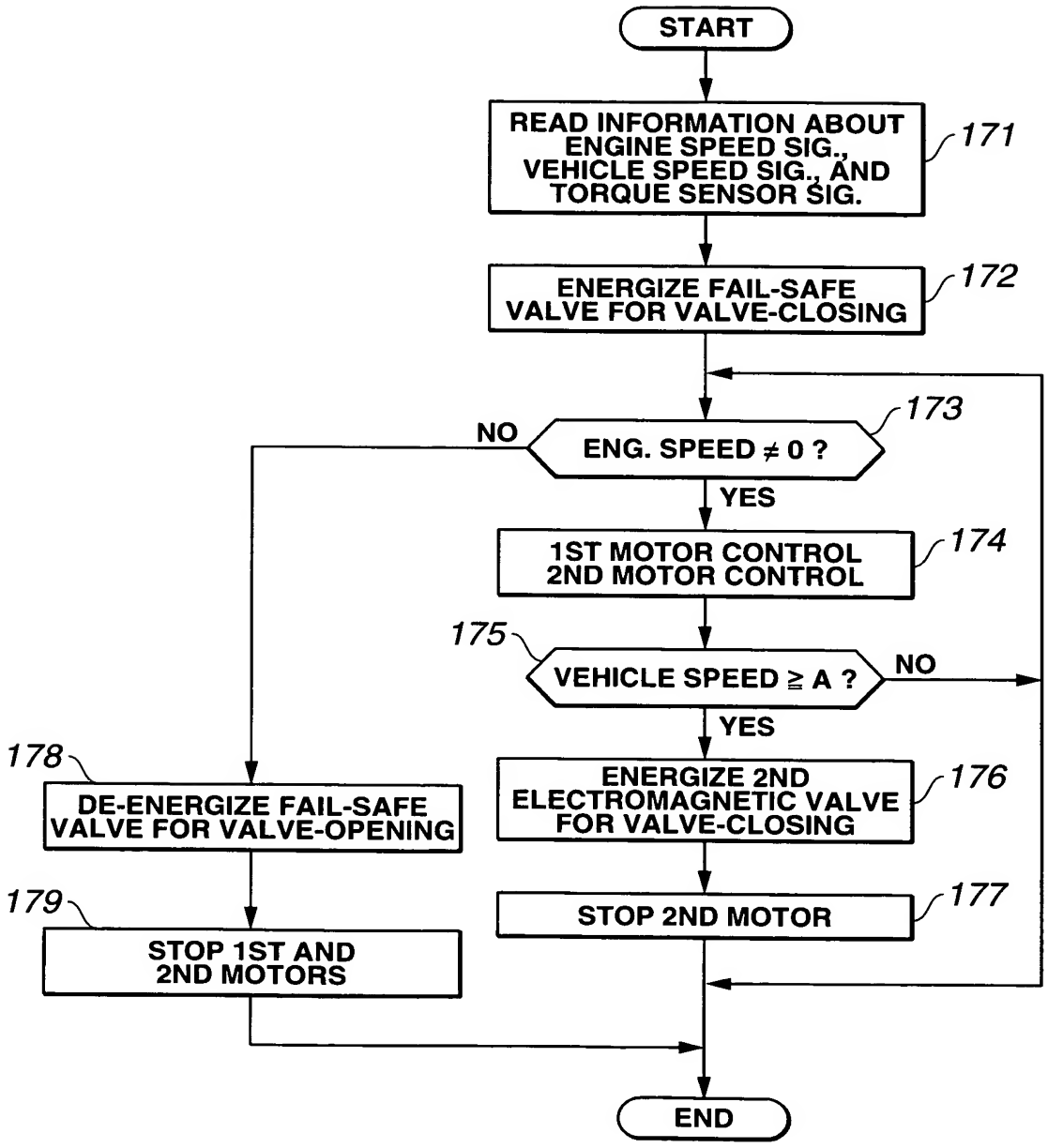
FIG.22



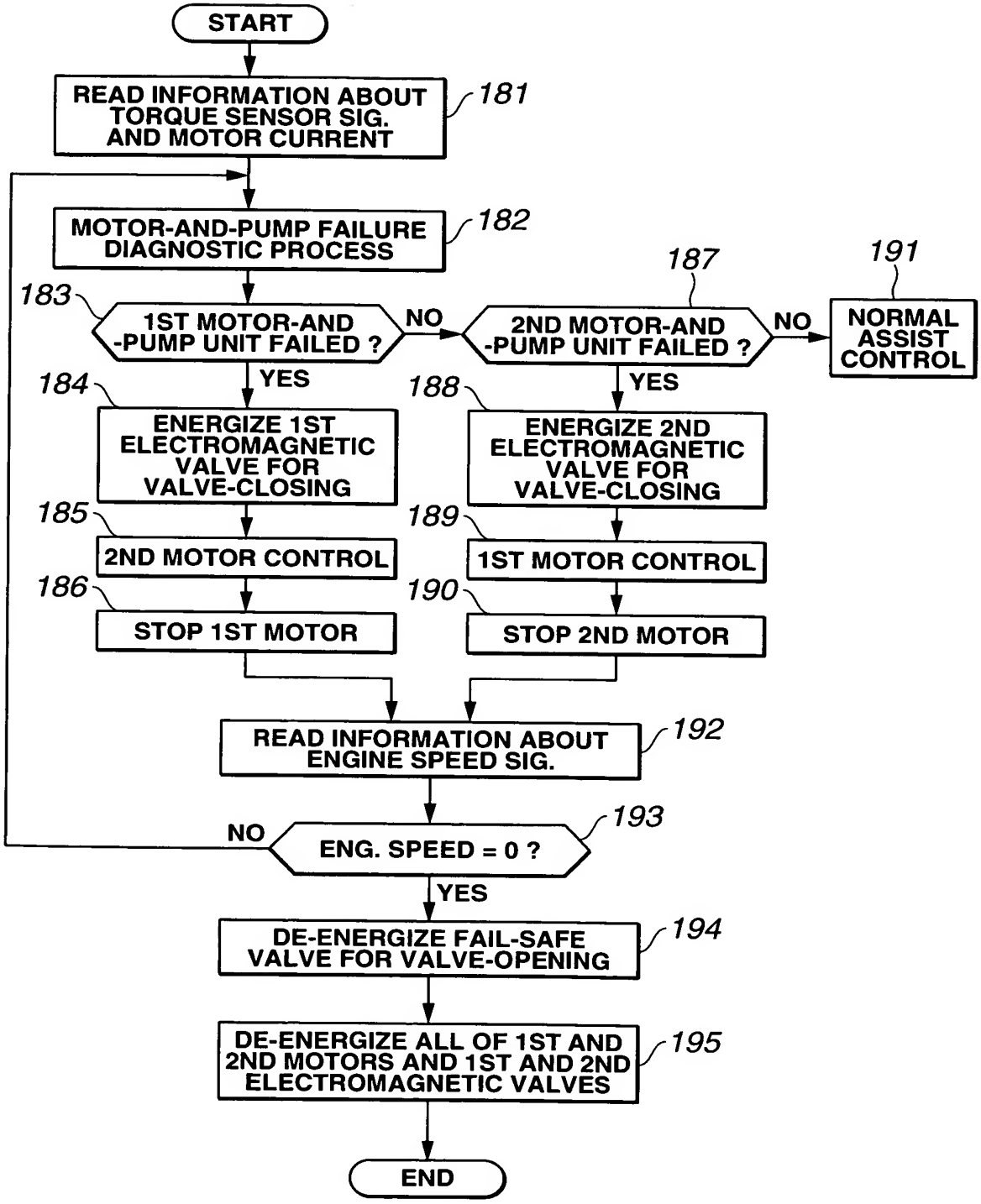
# FIG.23


VEHICLE SPEED SIG.
ENGINE SPEED SIG.
TORQUE SENSOR SIG.
ECU
M
M
14
24
8
51
23
6
49
48
49
7
18
26
11
52
9
10
25
12
50
1
53
2
53b
53a
54
18
32
3
17
16
5
4
15a
15
15b

# FIG.24


START
READ INFORMATION ABOUT ENGINE SPEED SIG., VEHICLE SPEED SIG., AND TORQUE SENSOR SIG.
171
ENERGIZE FAIL-SAFE VALVE FOR VALVE-CLOSING
172
173
NO
ENG. SPEED ≠ 0 ?
YES
1ST MOTOR CONTROL
2ND MOTOR CONTROL
174
175
VEHICLE SPEED ≧ A ?
NO
YES
178
DE-ENERGIZE FAIL-SAFE VALVE FOR VALVE-OPENING
ENERGIZE 2ND ELECTROMAGNETIC VALVE FOR VALVE-CLOSING
176
179
STOP 1ST AND 2ND MOTORS
STOP 2ND MOTOR
177
END

# FIG.25


START
READ INFORMATION ABOUT TORQUE SENSOR SIG. AND MOTOR CURRENT
181
MOTOR-AND-PUMP FAILURE DIAGNOSTIC PROCESS
182
183
1ST MOTOR-AND -PUMP UNIT FAILED ?
NO
187
2ND MOTOR-AND -PUMP UNIT FAILED ?
NO
191
NORMAL ASSIST CONTROL
YES
YES
184
ENERGIZE 1ST ELECTROMAGNETIC VALVE FOR VALVE-CLOSING
188
ENERGIZE 2ND ELECTROMAGNETIC VALVE FOR VALVE-CLOSING
185
2ND MOTOR CONTROL
189
1ST MOTOR CONTROL
186
STOP 1ST MOTOR
190
STOP 2ND MOTOR
READ INFORMATION ABOUT ENGINE SPEED SIG.
192
NO
ENG. SPEED = 0 ?
193
YES
DE-ENERGIZE FAIL-SAFE VALVE FOR VALVE-OPENING
194
DE-ENERGIZE ALL OF 1ST AND 2ND MOTORS AND 1ST AND 2ND ELECTROMAGNETIC VALVES
195
END

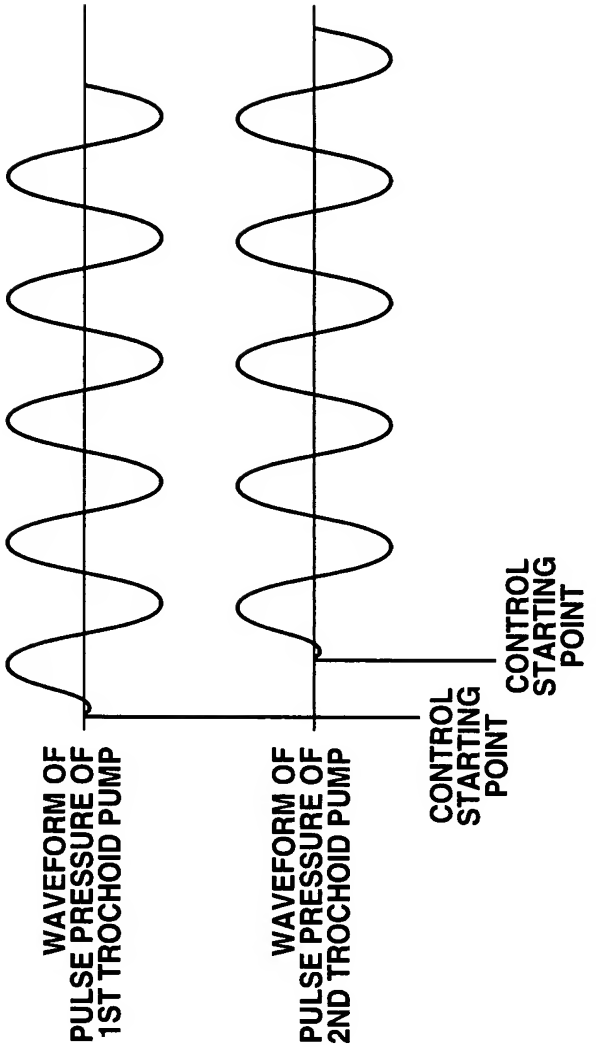



FIG.26A

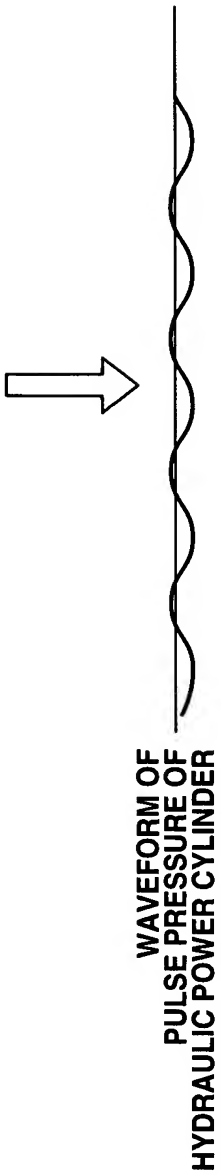



FIG.26B

# FIG.27

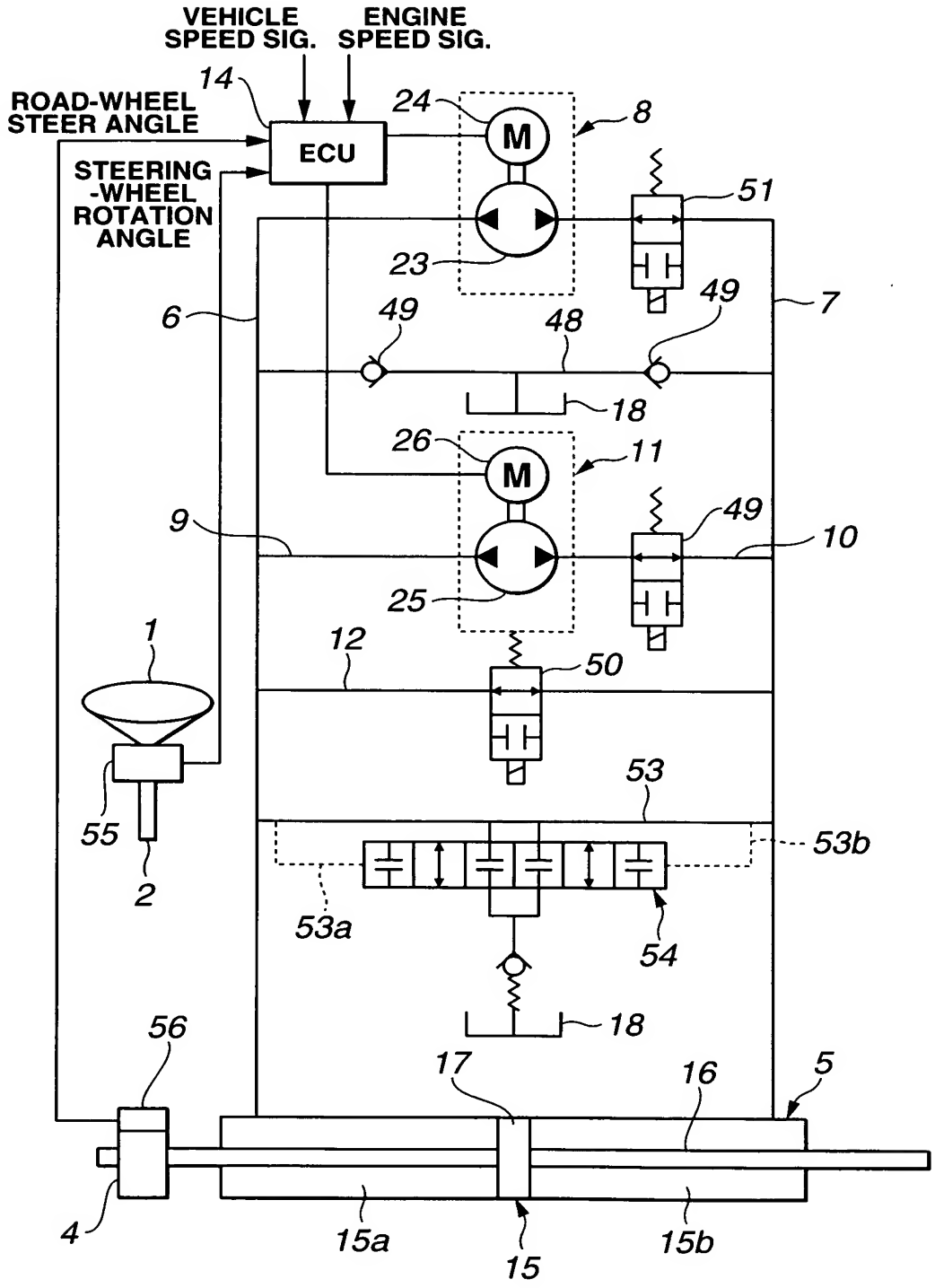
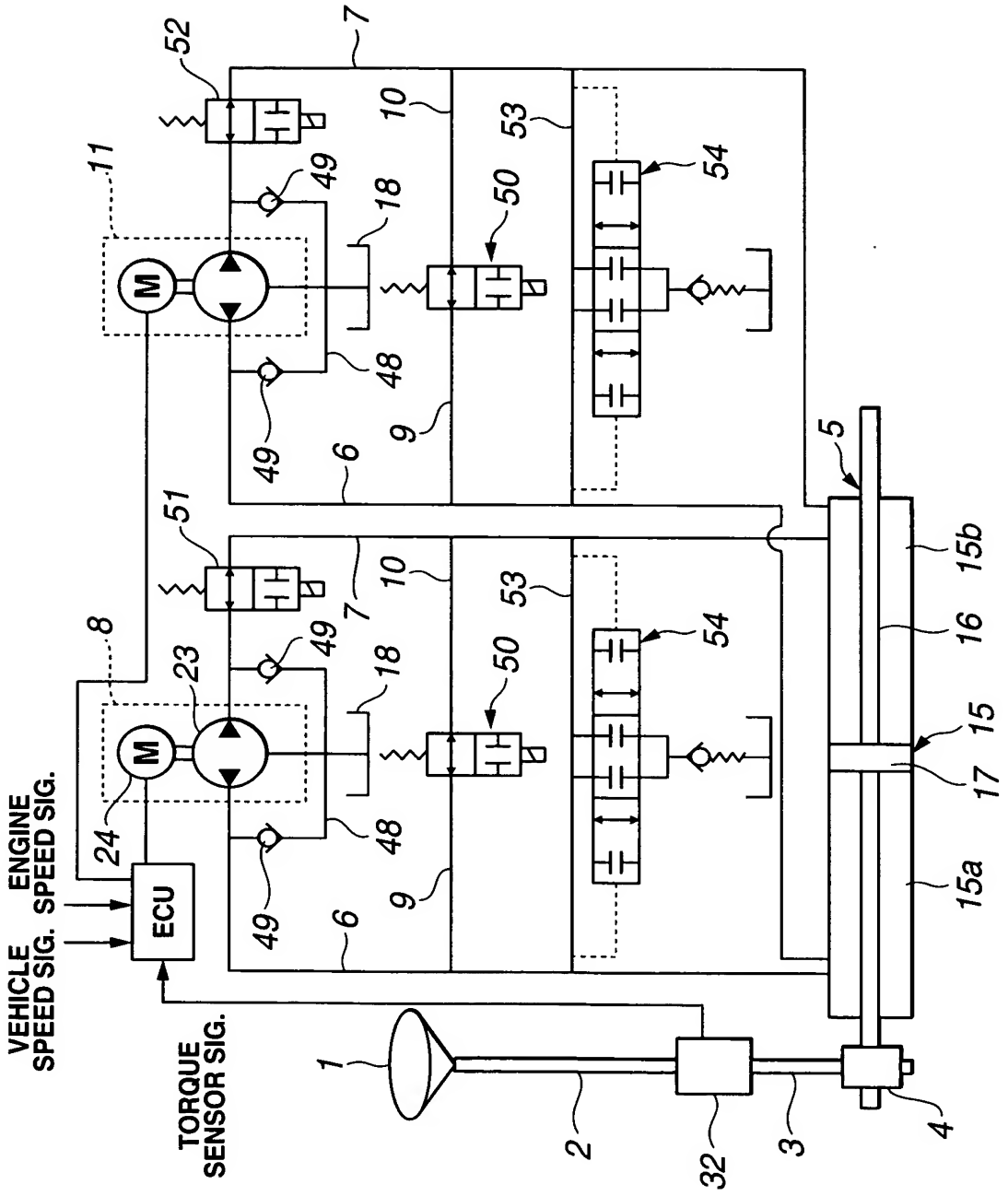
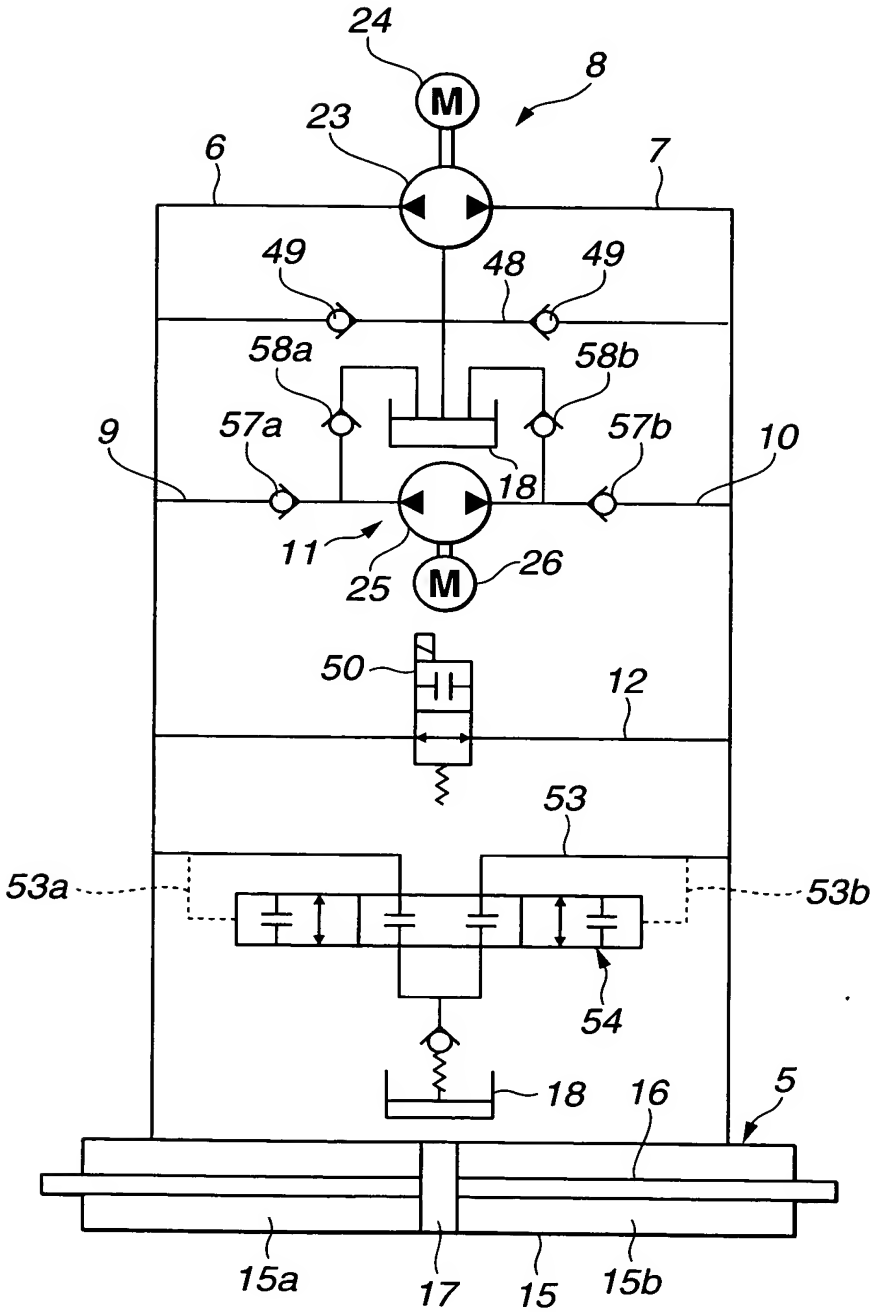

VEHICLE SPEED SIG.
ENGINE SPEED SIG.
ROAD-WHEEL STEER ANGLE
STEERING -WHEEL ROTATION ANGLE
ECU
14
24
8
M
51
23
49
7
6
48
18
26
11
9
10
25
12
50
1
53
55
2
53b
53a
54
56
17
16
5
4
15a
15
15b

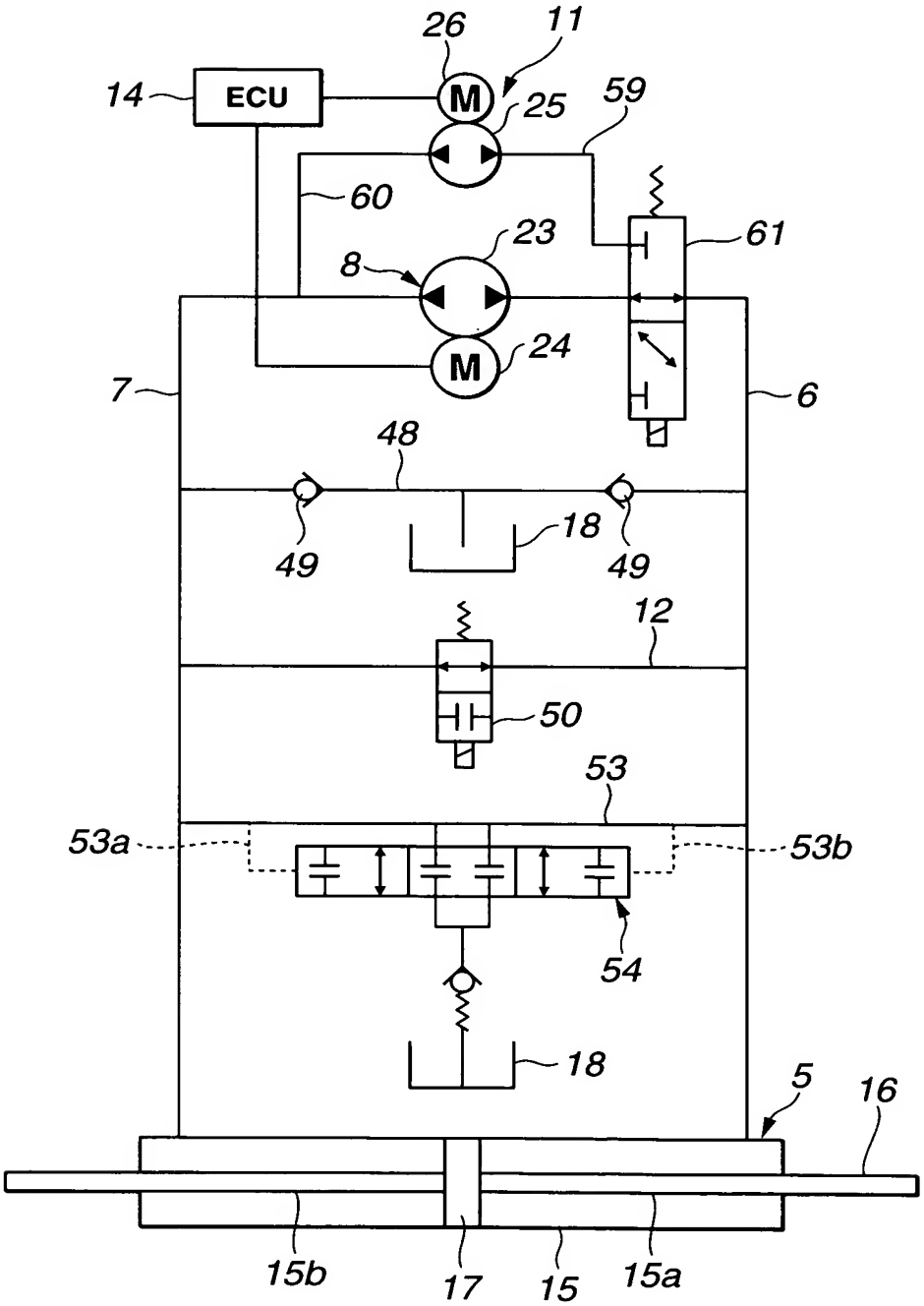
FIG.28


ENGINE SPEED SIG.
VEHICLE SPEED SIG.
TORQUE SENSOR SIG.
ECU
M
1
2
3
4
5
6
7
8
9
10
11
15
15a
15b
16
17
18
23
24
32
48
49
50
51
52
53
54

# FIG.29

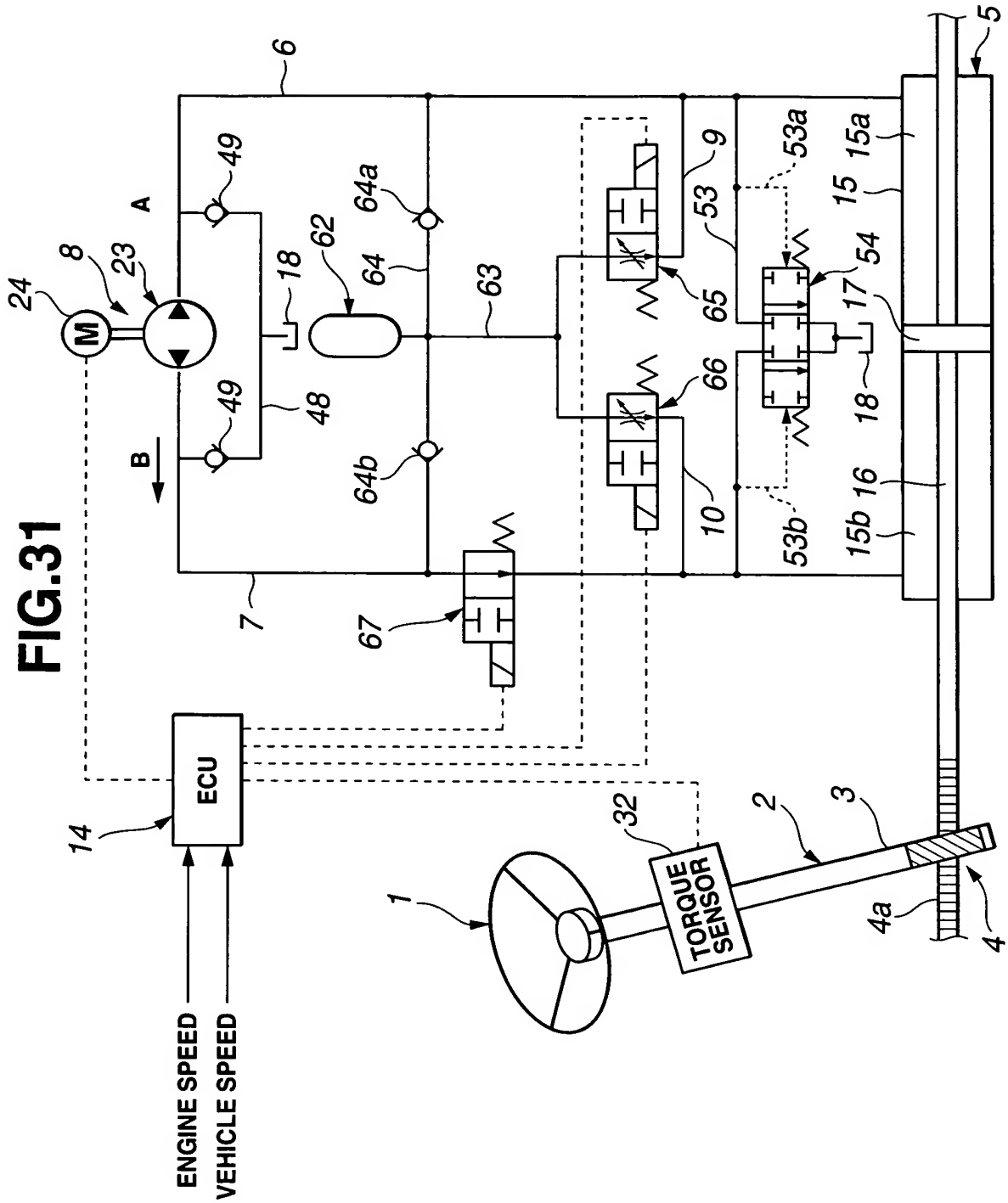

24
8
M
23
6
7
49
48
49
58a
58b
9
57a
57b
10
18
11
25
M
26
50
12
53
53a
53b
54
18
16
5
15a
17
15
15b

# FIG.30

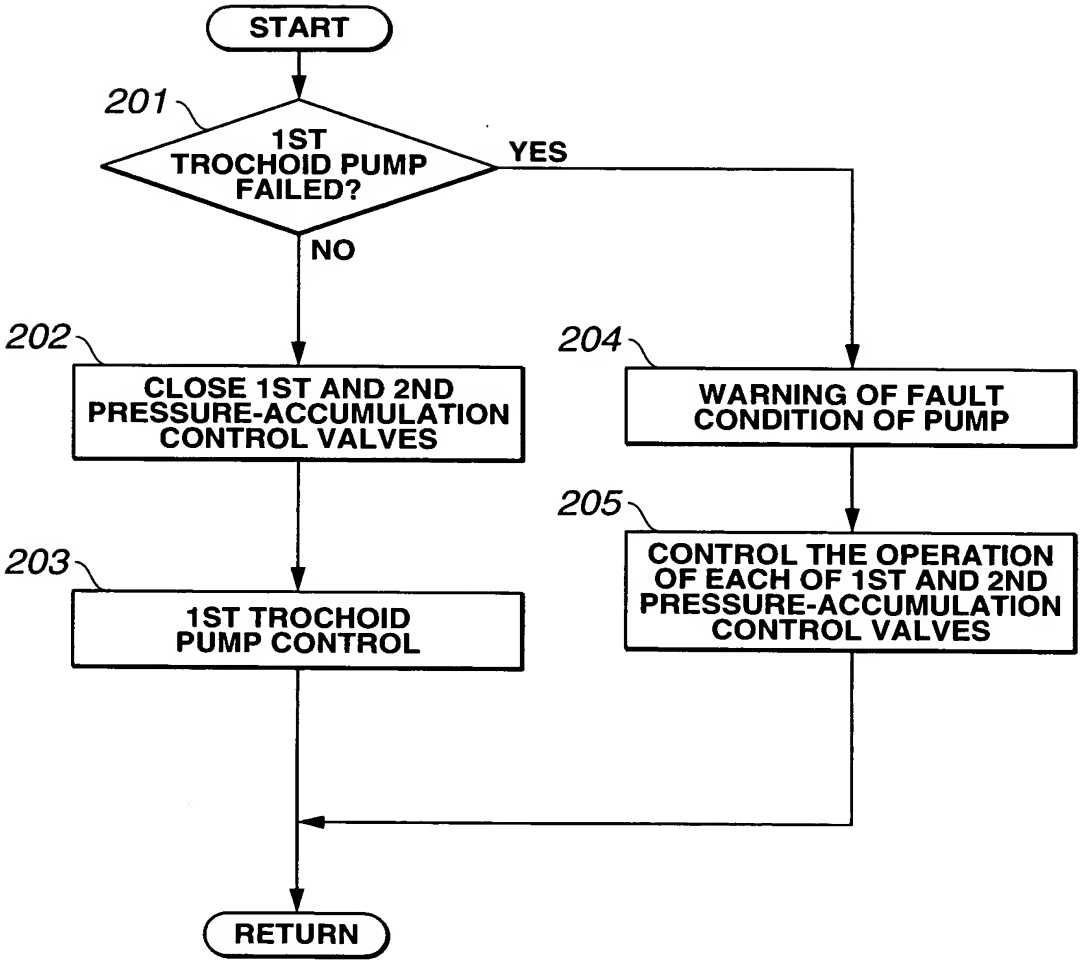

26
11
14
ECU
M
25
59
60
23
61
8
M
24
7
6
48
49
18
49
12
50
53
53a
53b
54
18
5
16
15b
17
15
15a

Title: POWER STEERING DEVICE AND METHOD OF CONTROLLING THE POWER STEERING DEVICE
Inventor(s): Mitsuo SASAKI et al.
DOCKET NO.: 023484-0222

FIG.31



# FIG.32


START
201
1ST TROCHOID PUMP FAILED?
YES
NO
202
CLOSE 1ST AND 2ND PRESSURE-ACCUMULATION CONTROL VALVES
203
1ST TROCHOID PUMP CONTROL
204
WARNING OF FAULT CONDITION OF PUMP
205
CONTROL THE OPERATION OF EACH OF 1ST AND 2ND PRESSURE-ACCUMULATION CONTROL VALVES
RETURN

# FIG.33

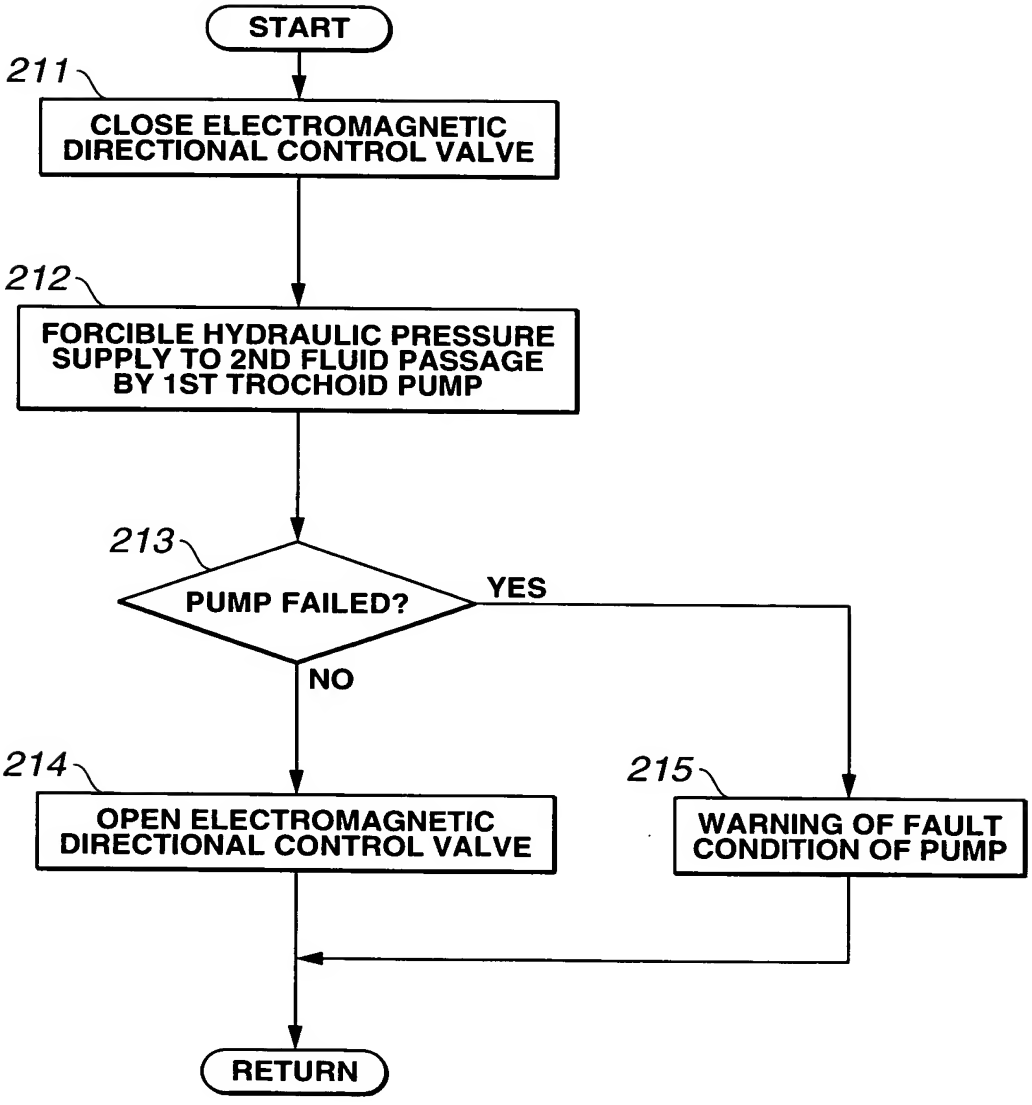
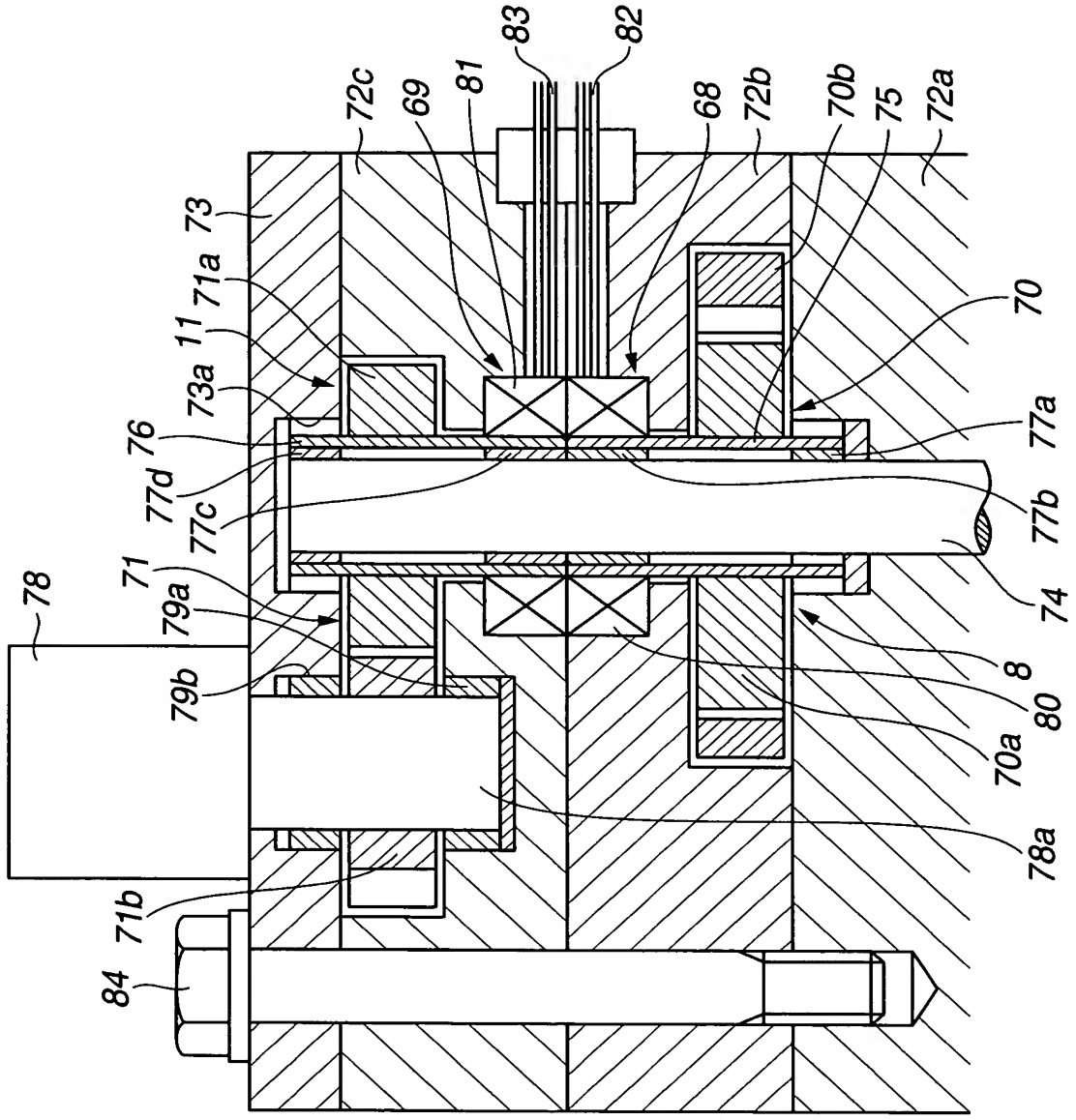
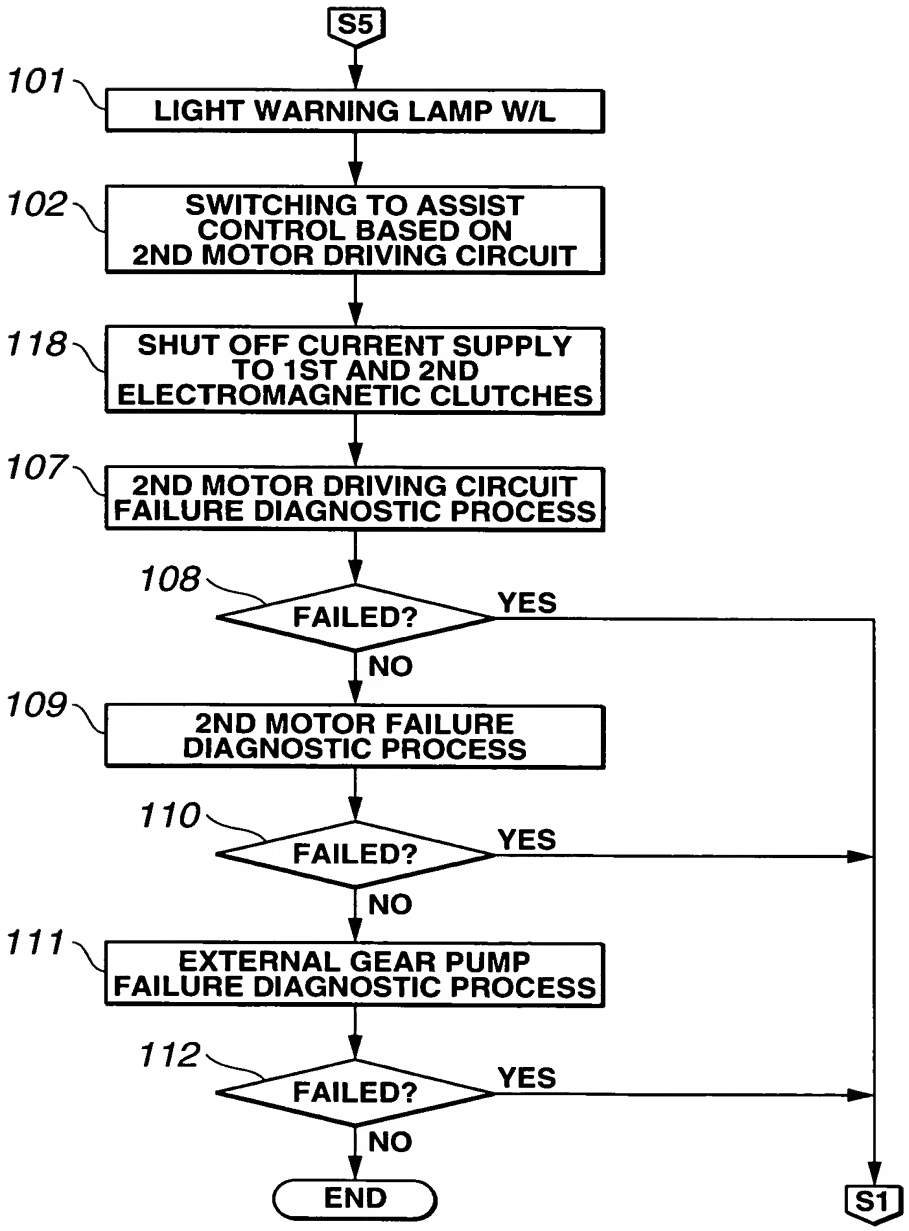

START
211
CLOSE ELECTROMAGNETIC DIRECTIONAL CONTROL VALVE
212
FORCIBLE HYDRAULIC PRESSURE SUPPLY TO 2ND FLUID PASSAGE BY 1ST TROCHOID PUMP
213
PUMP FAILED?
YES
NO
214
OPEN ELECTROMAGNETIC DIRECTIONAL CONTROL VALVE
215
WARNING OF FAULT CONDITION OF PUMP
RETURN

FIG.34


83
82
72c
69
81
68
72b
70b
75
72a
73
71a
11
70
73a
77a
76
77d
77c
77b
71
78
79a
74
79b
8
80
70a
78a
71b
84

# FIG.35


S5
101
LIGHT WARNING LAMP W/L
102
SWITCHING TO ASSIST CONTROL BASED ON 2ND MOTOR DRIVING CIRCUIT
118
SHUT OFF CURRENT SUPPLY TO 1ST AND 2ND ELECTROMAGNETIC CLUTCHES
107
2ND MOTOR DRIVING CIRCUIT FAILURE DIAGNOSTIC PROCESS
108
FAILED?
YES
NO
109
2ND MOTOR FAILURE DIAGNOSTIC PROCESS
110
FAILED?
YES
NO
111
EXTERNAL GEAR PUMP FAILURE DIAGNOSTIC PROCESS
112
FAILED?
YES
NO
END
S1

# FIG.36